ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
Washington, D.C. Ottawa, Ontario
30 SEPTEMBER 1967

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

CANADA · UNITED STATES

CANADIAN SECTION
G. M. MacNABB, Chairman
A. F. PAGET, Member

UNITED STATES SECTION
W. E. JOHNSON, Chairman
M. D. DUBROW, Member

31 December 1967

The Honourable Dean Rusk
The Secretary of State
Washington, D.C.

The Honourable Jean-Luc Pepin
Minister of Energy, Mines and Resources
Ottawa, Ontario

Gentlemen:

Reference is made to the Treaty between the United States of America and Canada, relating to co-operative development of the water resources of the Columbia River basin, signed at Washington, D.C. on 17 January 1961.

In accordance with the provisions of Article XV paragraph 2(e), there is submitted herewith the third Annual Report, dated 30 September 1967, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1966 to 30 September 1967.

Respectfully submitted:

For the United States

Wendell E. Johnson, Chairman

Morgan D. Dubrow

For Canada

G.M. MacNabb, Chairman

A.F. Paget

DUNCAN DAM and RESERVOIR—the first of the Treaty projects to be completed.

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SUMMARY

The third Annual Report of the Permanent Engineering Board is submitted to the Governments of the United States and Canada in compliance with Article XV of the Columbia River Treaty of January 1961. Project construction, progress of Entity studies, and benefits realized from completion of Duncan Dam are described.

Four Board meetings and two meetings of the Board with the Entities were held during the reporting period. The Board also inspected the Libby project and the three Canadian projects during the month of August.

Completion of Duncan Dam on 31 July 1967 entitled Canada to a flood control payment of $11,100,000 in United States funds. The early completion also provided additional energy and flood control benefits to both countries.

The Arrow project is ahead of schedule and is expected to be in operation before the scheduled date of 1 April 1969. Work on the Mica and Libby projects is on schedule.

Studies concerning the hydrometeorological network, project discharge works, power and flood control operation and reservoir filling are being continued by the Entities to ensure operation of the projects in accordance with the terms of the Treaty.

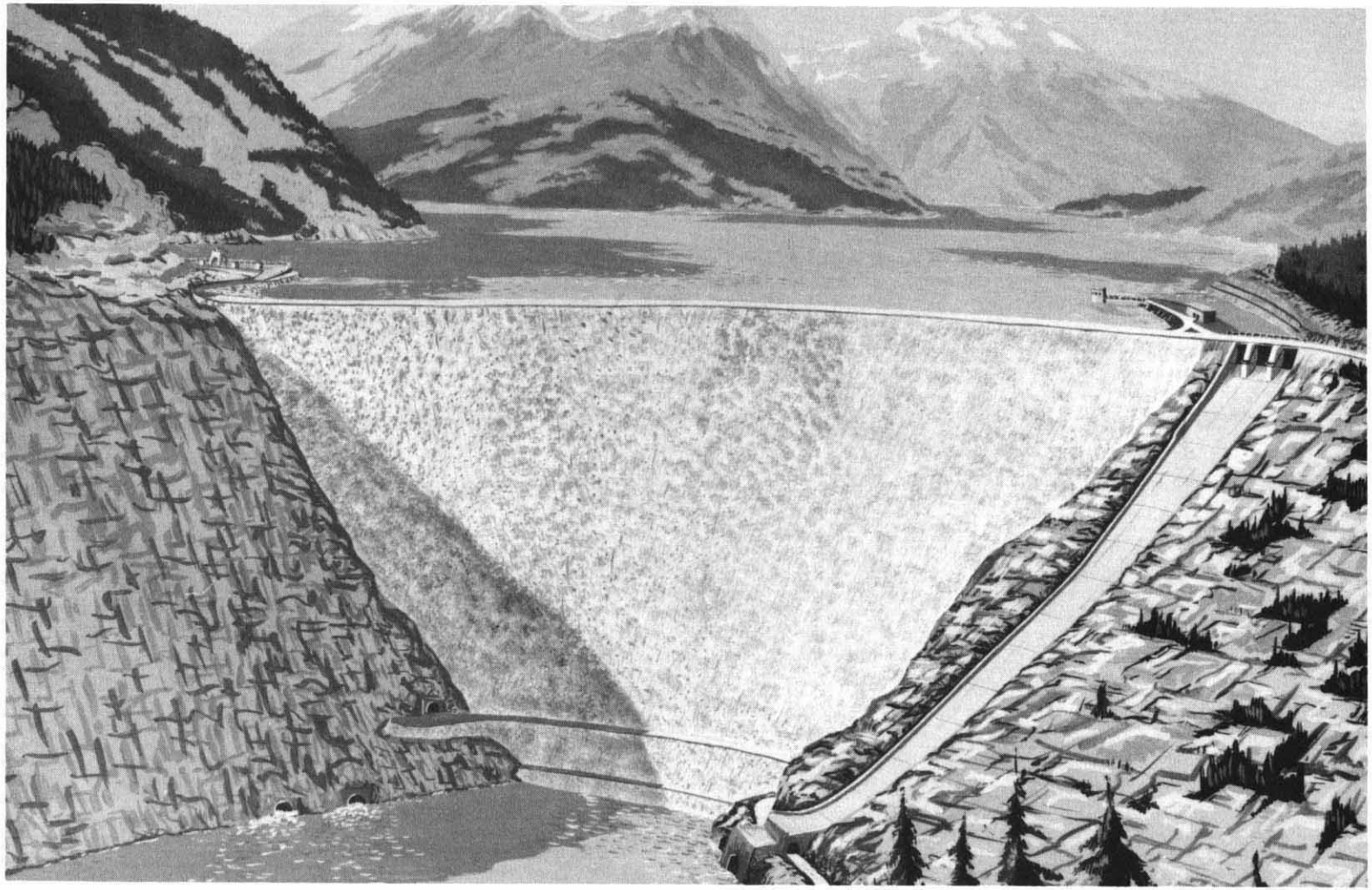
The Board concludes that the objectives of the Treaty are being met.

INTRODUCTION

The Columbia River Treaty, which provides for co-operative development of the water resources of the Columbia River basin, was signed at Washington, D.C. on 17 January 1961 by representatives of the United States and Canada. The Treaty will provide each country with substantially greater benefits than if separate plans of improvement had been undertaken independently by either nation.

Article XV of the Treaty established a Permanent Engineering Board and specified that one of its duties would be to "make reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty . . .".

This Annual Report, which covers the period 1 October 1966 to 30 September 1967, indicates progress being achieved by both countries under the terms of the Treaty and the benefits being realized from operation of Treaty projects. The report also indicates whether, in the opinion of the Board, the objectives of the Treaty are being met. Summaries of the essential features of the Treaty and of the responsibilities of the Board and of the Entities are included.



MICA PROJECT

Columbia River, British Columbia

An artist's conception of the completed project. The discharge tunnels from the underground powerhouse can be seen in the far bank.

THE COLUMBIA RIVER TREATY

General

The Columbia River Treaty was signed in Washington, D.C. on 17 January 1961 and was ratified by the United States Senate in March of that year. In Canada ratification was delayed. Further negotiations between the two countries resulted in formal agreement by an exchange of notes on 22 January 1964 to a Protocol to the Treaty and to an Attachment Relating to Terms of Sale. The Treaty and related documents were approved by the Canadian Parliament in June 1964.

The Canadian Entitlement Purchase Agreement was signed on 13 August 1964. Under the terms of this agreement Canada's share of downstream power benefits resulting from the first thirty years of scheduled operation of each of the storage projects was sold to a group of electric utilities in the United States known as the Columbia Storage Power Exchange.

On 16 September 1964 the Treaty and Protocol were formally ratified by an exchange of notes between the two governments. A check for $253.9 million (U.S. funds) was delivered to the Canadian representatives as payment in advance for the Canadian entitlement to downstream power benefits during the period of the Purchase Agreement. On the same date at a ceremony at the Peace Arch Park on the International Boundary the Treaty and its Protocol were proclaimed by President Johnson, Prime Minister Pearson, and Premier Bennett of British Columbia.

Features of the Treaty and Related Documents

The essential features of the Treaty are as follows:

(a) Canada will provide 15.5 million acre-feet of usable storage by constructing dams near Mica Creek, the outlet of Arrow Lakes, and Duncan Lake, in British Columbia.

(b) The United States will maintain and operate hydroelectric power facilities included in the base system and any new main-stem projects to make the most effective use of improved stream flow resulting from operation of the Canadian storage. Canada will operate the storage in accordance with procedures and operating plans specified in the Treaty.

(c) The United States and Canada will share equally the additional power generated in the United States as a result of river regulation by upstream storage in Canada.

(d) On commencement of the respective storage operations the United States will make payments to Canada totalling $64.4 million (U.S. funds) for flood control provided by Canada.

(e) The United States has the option of constructing a dam on the Kootenai River near Libby, Montana. The Libby reservoir would extend some 42 miles into Canada and Canada would make the necessary Canadian land available for flooding.

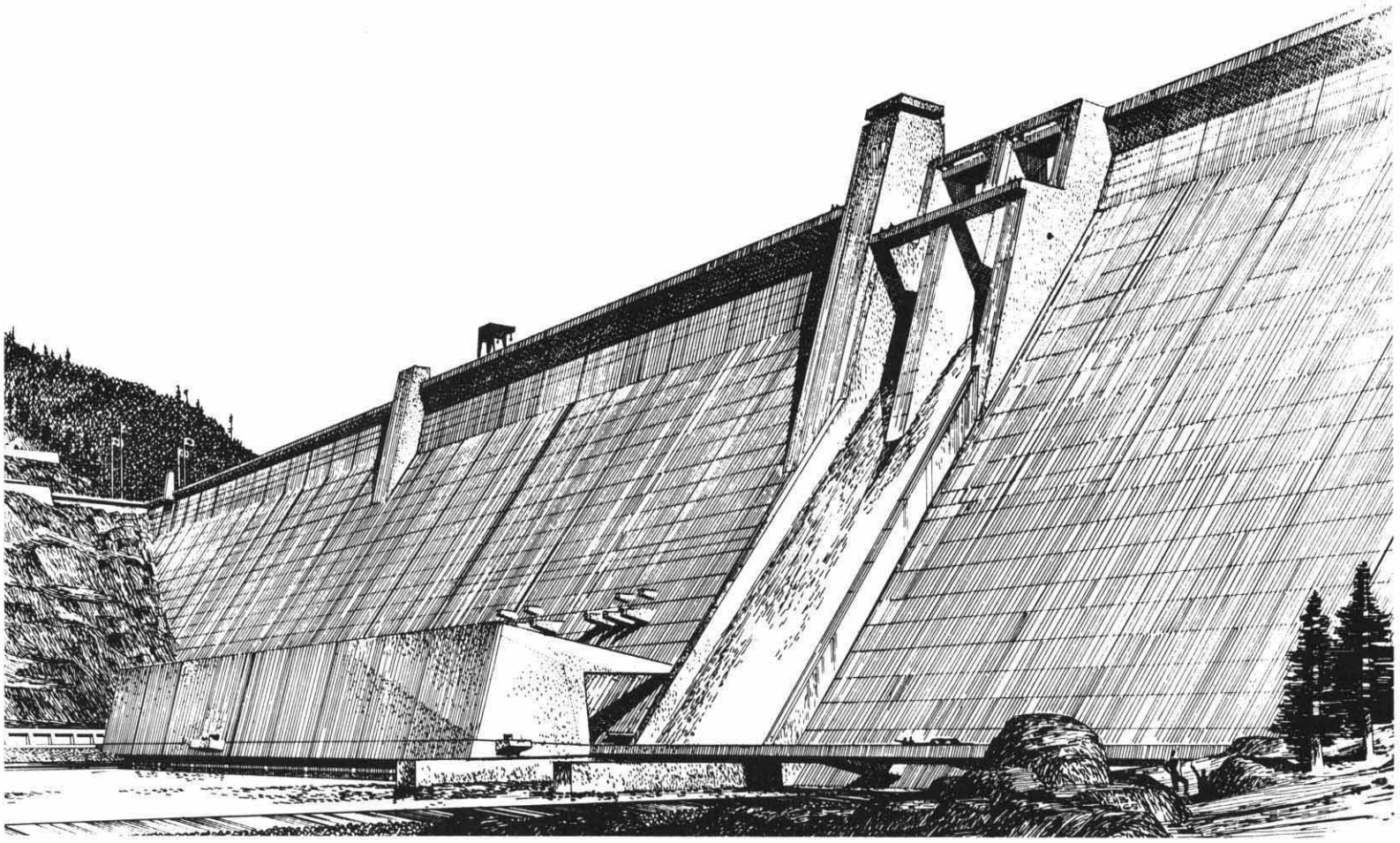
(f) Canada has the option of making specific diversions of the Kootenay River.

(g) Differences arising under the Treaty which cannot be resolved by the two countries may be referred by either to the International Joint Commission or to arbitration by an appropriate tribunal as specified by the Treaty.

(h) The Treaty shall remain in force for at least 60 years from its date of ratification, 16 September 1964.

The Protocol of January 1964 amplified and clarified certain terms of the Columbia River Treaty. The Attachment Relating to Terms of Sale signed on the same date established agreement that under certain terms Canada would sell in the United States its entitlement to downstream power benefits for a 30-year period. The Canadian Entitlement Purchase Agreement of 13 August 1964 provided that the Treaty storages would be operative for power purposes on the following dates:

Duncan storage	1 April 1968
Arrow storage	1 April 1969
Mica storage	1 April 1973



LIBBY PROJECT

Kootenai River, Montana

A perspective drawing of the dam and powerhouse.

PERMANENT ENGINEERING BOARD

General

Article XV of the Columbia River Treaty established a Permanent Engineering Board consisting of two members to be appointed by Canada and two members by the United States. Appointments to the Board were to be made within three months of the date of ratification. The duties and responsibilities of the Board were also stipulated in the Treaty and related documents.

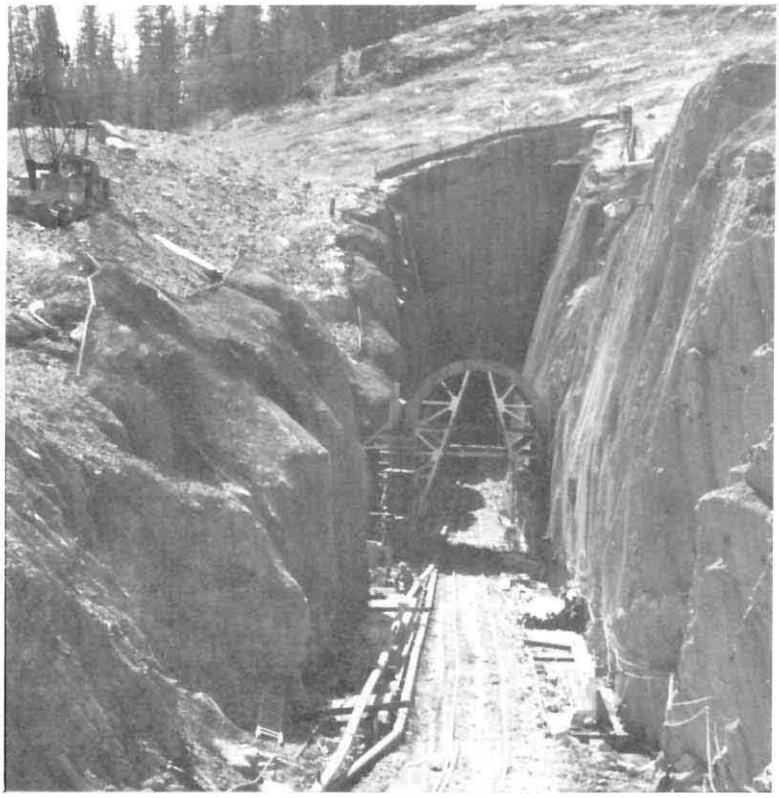
Establishment of the Board

Pursuant to Executive Order No. 11177 dated 16 September 1964 the Secretary of the Army and the Secretary of the Interior on 7 December 1964 appointed two members and two alternate members to form the United States Section of the Permanent Engineering Board. The members of the Canadian Section of the Board were appointed by Order in Council P.C. 1964-1671 dated 29 October 1964. Each member was authorized to appoint an alternate member. On 11 December 1964 the two governments announced the composition of the Board.

The names of the Board members, alternate members and secretaries are shown in Appendix A.

RAILWAY TUNNEL

The north portal of the seven-mile long tunnel for the relocation of the Great Northern rail line.
Libby Project,
31 August 1967



Duties and Responsibilities of the Board

The general duties and responsibilities of the Board to the governments, as set forth in the Treaty and related documents, include:

(a) assembling records of the flows of the Columbia River and the Kootenay River at the Canada–United States of America boundary;

(b) reporting to Canada and the United States of America whenever there is substantial deviation from the hydroelectric and flood control operating plans and if appropriate including in the report recommendations for remedial action and compensatory adjustments;

(c) assisting in reconciling differences concerning technical or operational matters that may arise between the entities;

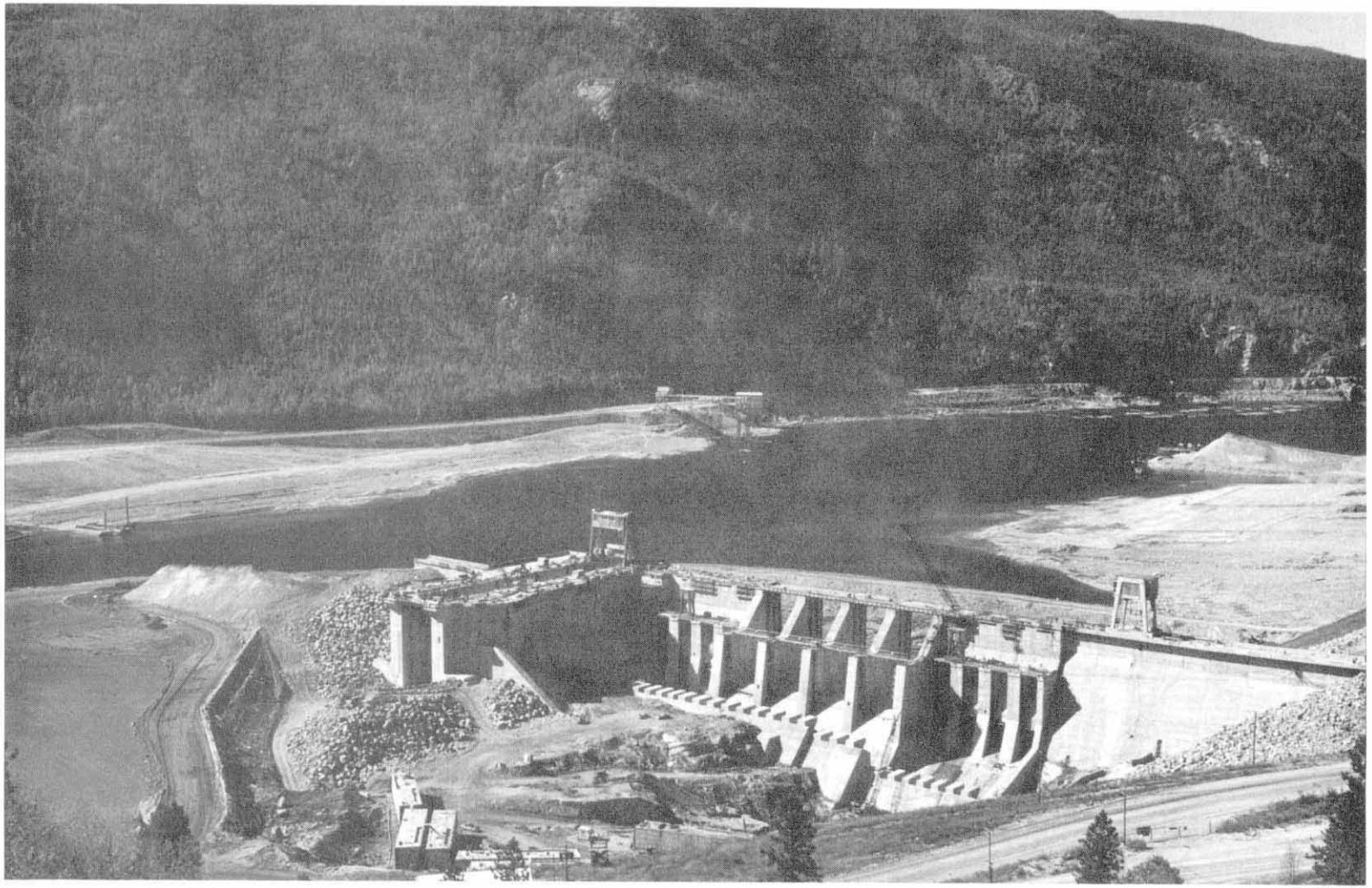
(d) making periodic inspections and requiring reports as necessary from the entities with a view to ensuring that the objectives of the Treaty are being met;

(e) making reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and making special reports concerning any matter which it considers should be brought to their attention;

(f) investigating and reporting with respect to any other matter coming within the scope of the Treaty at the request of either Canada or the United States of America;

(g) consulting with the entities in the establishment and operation of a hydro-meteorological system as required by Annex A of the Treaty.

In addition to these duties Article XV(4) of the Treaty states that the Board shall comply with directions, relating to its administration and procedures, agreed upon by the two governments as evidenced by an exchange of notes. A document entitled "Administration and Procedures", prepared by the Board, was approved by the two governments by a formal exchange of notes on 4 October 1965 and is included as Appendix C to this report. Since approval of this document a change in Departmental responsibility has occurred in the Canadian Government. The Canadian Section of the Board now reports to the Minister of Energy, Mines and Resources.



ARROW PROJECT

Columbia River, British Columbia

The project three weeks before the cofferdam area was rewatered; concrete work is virtually complete. 7 September 1967

ENTITIES

General

Article XIV(1) of the Treaty provides for the designation by Canada and the United States of entities which are empowered and charged with the duty of formulating and executing the operating arrangements necessary to implement the Treaty. Provision is made for either government to designate one or more entities. The powers and duties of the entities are specified in the Treaty and related documents.

Establishment of the Entities

Executive Order No. 11177, previously referred to, designated the Administrator of the Bonneville Power Administration, Department of the Interior, and the Division Engineer, North Pacific Division, Corps of Engineers, Department of the Army, as the United States Entity with the Administrator to serve as Chairman. Order in Council P.C. 1964-1407 dated 4 September 1964 designated the British Columbia Hydro and Power Authority as the Canadian Entity for the purposes of the Treaty.

The names of the members of the two entities are shown in Appendix B. It is noted that Mr. David S. Black, formerly Chairman of the United States Entity, has been appointed Undersecretary of the Department of the Interior, Washington, D.C., and Mr. H.R. Richmond is Acting Chairman of the United States Entity. It is also noted that Brigadier General Elmer P. Yates has replaced Brigadier General Peter C. Hyzer as member of the United States Entity.

Powers and Duties of the Entities

In addition to the powers and duties specified elsewhere in the Treaty and related documents the Treaty requires that the entities be responsible for:

(a) co-ordination of plans and exchange of information relating to facilities to be used in producing and obtaining the benefits contemplated by the Treaty,

(b) calculation of and arrangements for delivery of hydroelectric power to which Canada is entitled for providing flood control,

(c) calculation of the amounts payable to the United States of America for standby transmission services,

(d) consultation on requests for variations made pursuant to Articles XII(5) and XIII(6),

(e) the establishment and operation of a hydrometeorological system as required by Annex A,

(f) assisting and co-operating with the Permanent Engineering Board in the discharge of its functions,

(g) periodic calculation of accounts,

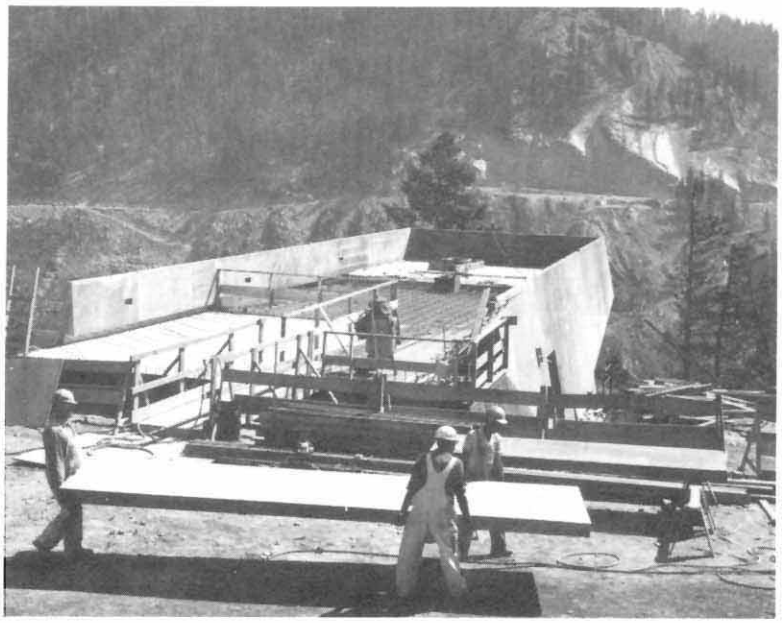
(h) preparation of the hydroelectric operating plans and the flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled,

(i) preparation of proposals to implement Article VIII and carrying out any disposal authorized or exchange provided for therein,

(j) making appropriate arrangements for delivery to Canada of the downstream power benefits to which Canada is entitled including such matters as load factors for delivery, times and points of delivery, and calculation of transmission loss,

(k) preparation and implementation of detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under the plans referred to in Annexes A and B.

Article XIV(4) of the Treaty provides that the two governments may, by an exchange of notes, empower or charge the entities with any other matter coming within the scope of the Treaty.



VISTA STRUCTURE
at the Libby Project overlooks the dam site and the rock cut for Montana State Highway 37 on the left abutment.
29 August 1967

ACTIVITIES OF THE BOARD

Meetings

The first Board meeting of the report year was held in San Francisco, California on 21-22 November 1966 to complete the Board's second Annual Report. The second meeting was held in Seattle, Washington on 8 March 1967 to review progress of Entity studies. A joint meeting was held with the Entities on the following day to discuss progress and a draft of a special operating program for the Duncan project. The third meeting of the Board was held in Washington, D.C. on 25 May 1967 to discuss progress of project construction and Entity studies submitted to the Board. The final Board meeting of the report year was held in Vancouver, B.C. on 4 August 1967 to review progress and on the same day a joint meeting was held with the Entities to receive information on Entity studies.

Field Inspections

During the period 31 July through 3 August 1967 the Board visited the Libby project and the three Canadian Treaty projects to assess construction progress.

Reports Received

The Board continued to receive monthly reports from the Canadian Entity indicating construction progress of the Canadian Treaty projects.

Quarterly progress reports were received from the Entities on their studies relating to the hydrometeorological network, reservoir filling plans, project discharge capacity, power operating plans and flood control operating plans. These reports also indicated construction progress of the Libby project.

The Entities reached agreement on a revised minimum average weekly outflow from the Duncan project and in November 1966 provided the Board with a copy of their signed agreement. The Entities also agreed on procedures to be followed during a period of trial filling and test operation for the Duncan project and in March 1967 provided the Board with a draft of the document "Special Operating Program for the Duncan Reservoir for the Period April 30, 1967 through March 31, 1968".

In July 1967 the Entities supplied the Board with their agreed proposal for definition of the Treaty Hydrometeorological System Network. In August 1967 the Entities provided the Board with the following documents on which they had reached agreement:

- Program for Initial Filling of Arrow Reservoir Fully Operative April 1, 1969
- Program for Filling Duncan Reservoir April 1, 1968 – June 30, 1968
- Program for Initial Filling of Mica Reservoir
- Statistical Analysis of the Filling of Mica Reservoir
- Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans for Canadian Treaty Storage
- Operating Program for Duncan Reservoir During the Period 31 July 1967 through 31 March 1968
- Hydrometeorological Network Recommendation No. 4

COFFERDAM REMOVAL

Blasting the cut-off wall of the upstream cofferdam at the Arrow Project. The sequence of explosions was from left to right.
3 October 1967.

At the end of the report year the Board also received the following documents concerning the hydrometeorological network:

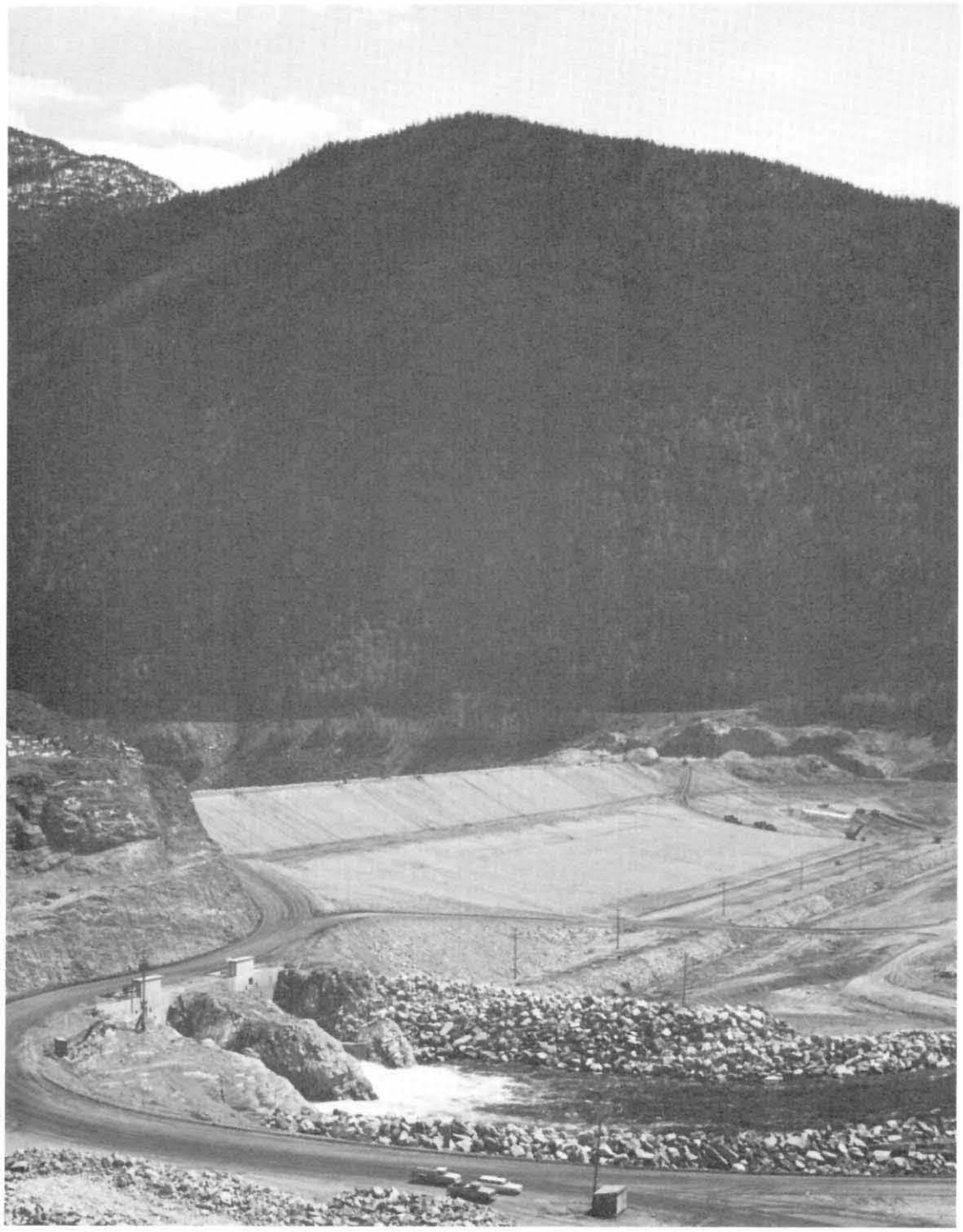
- Hydrometeorological Network Recommendation No.3 (meteorological stations)
- Hydrometeorological Network Classification of Stations
- Hydrometeorological Network Supporting Facilities.

Committee

As provided for by section 7 of the Board's Administration and Procedures, a committee was established in August 1967 to assist the Board in considering proposals and operating plans received from the Entities.

Report to Governments

The second Annual Report of the Board was submitted to the two governments on 31 December 1966.



DUNCAN DAM — Duncan River, British Columbia

The earthfill dam and the spillway in the far abutment viewed from above the discharge tunnel outlets after the reservoir began to fill. 18 May 1967

PROGRESS

General

The results achieved under the terms of the Treaty include construction progress on the Treaty projects and progress on studies regarding development of the hydrometeorological network, reservoir filling plans, power and flood control operating plans, and project discharge works. The locations of the Treaty projects are shown on Plate 1.

During the year the Duncan project was completed and placed in operation. It has produced both power and flood control benefits.

Construction Progress of the Treaty Projects

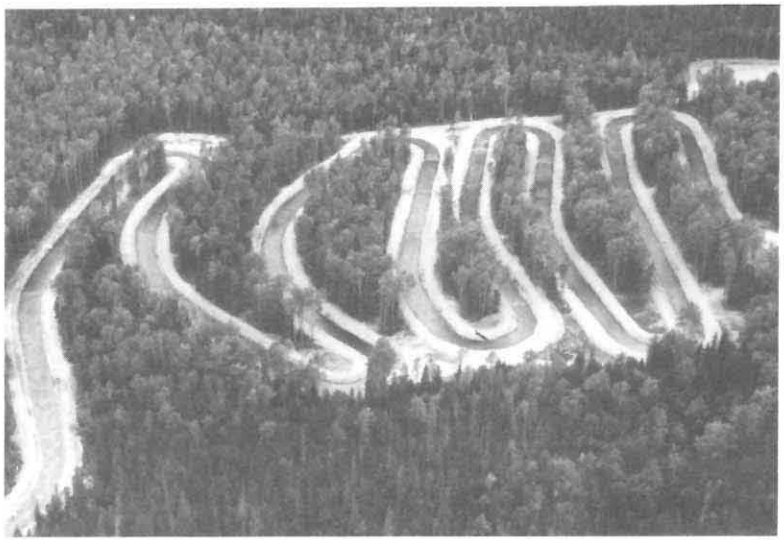
Duncan Project

Duncan Dam, scheduled by the Sales Agreement to be operative for stream-flow regulation by 1 April 1968, was declared operational by the Canadian Entity on 31 July 1967, well in advance of the Treaty requirements. British Columbia's Premier W.A.C. Bennett officially opened Duncan Dam on 17 August 1967.

The general arrangement of the completed structures, as shown on Plate 2, includes a zoned earthfill dam built across the flat floor of the Duncan River valley between the steep valley walls. Discharge from the reservoir is regulated by radial gates at

SPAWNING CHANNEL

for Kokanee salmon; constructed to replace spawning grounds flooded by the Duncan Project.
19 August 1967



the downstream end of two tunnels in the right abutment and spillway facilities are located on the left abutment.

Drawings of the earthfill dam, discharge works, and spillway channel are shown on plate 3; the frontispiece and the picture on page 17 show the completed project.

Arrow Project

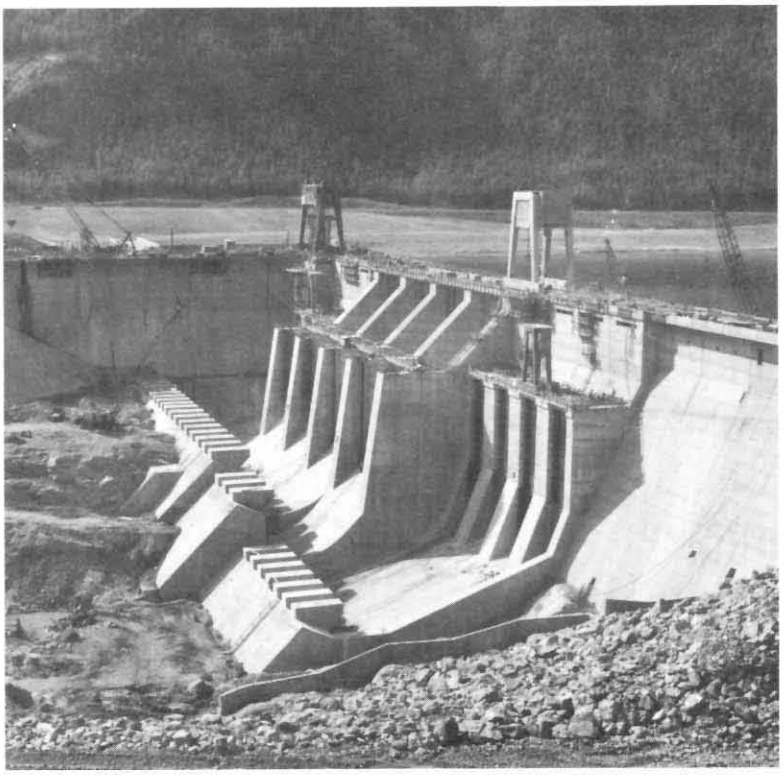
The Arrow dam, scheduled by the Sales Agreement for operation by 1 April 1969, will be the next Treaty project to become operative. It is expected that this project will be placed in operation before the scheduled date.

As shown on Plate 4, the Arrow project will consist of two main components: the concrete gravity structures including the spillway, low-level outlets, and navigation lock; and a zoned earthfill embankment with an impervious upstream blanket across the present river channel. Construction is proceeding satisfactorily and is well ahead of schedule.

The placing of concrete is complete except for work required on the spillway sections after closure of the earthfill section of the dam has been completed. The installation of gate guides, cranes and other equipment is well advanced. Demolition of the cofferdam is proceeding.

Progress of construction of the earthfill dam is illustrated on Plate 5. The placing of fill for this structure is well ahead of schedule.

Acquisition of land and relocation or dyking of certain communities to prepare the reservoir area are proceeding satisfactorily. Reservoir clearing is approximately 80% complete.



DISCHARGE WORKS
at the Arrow Project. The downstream faces of the spillway openings, the low-level ports, and the energy dissipators.
6 September 1967

Mica Project

Mica dam, the largest of the Treaty projects, is scheduled by the Sales Agreement for initial operation on 1 April 1973.

The general arrangement of structures for the Mica project is shown on Plate 6. The main dam will have a nearly vertical impervious core supported between zones of coarser material. During construction the site of the main fill will be dewatered by diverting the river through two 45-foot diameter tunnels in the left abutment. Spillway facilities and control works to provide regulated discharges from storage will be constructed in the left abutment and power facilities will be located in the right abutment.

DIVERSION TUNNEL No.2
at the Mica Project.
Looking upstream at the serrations for one of the tunnel plugs.
24 May 1967

A profile of one of the two 45-foot diameter diversion tunnels is shown on Plate 7. The placing of concrete in both tunnels is virtually complete and installation of intake gates is proceeding. The tunnel intake and outlet cofferdams are being removed.

An extensive program of relocation or reconstruction of approximately 90 miles of highway has been undertaken for this project. As shown on Plate 8, replacement of bridges and grading are complete. Nearly half of the highway has been paved.

A contract for approximately $136 million for construction of the dam, spillway, outlet works and power intake was awarded on 6 September 1967 to Mica Dam Contractors, a consortium of Guy F. Atkinson Company, San Francisco, California; Commonwealth Construction Company Limited and Dillingham Corporation Canada Limited, both of Vancouver, British Columbia; The Arundel Corporation, Baltimore, Maryland; and L.E. Dixon Company, San Gabriel, California. The contractor is on the site and construction of cofferdams and excavation of river overburden are scheduled for this winter.

Libby Project

Libby dam is the fourth and last of the Treaty projects to be placed under construction. Initial phases, including highway and railroad relocations, were commenced in June 1966. In accordance with Article XII of the Treaty the outlet facilities at the dam should be fully operable by 30 June 1973.

The general arrangement of the structures is shown on Plate 9, and the reservoir area and the required highway and railroad relocations are depicted on Plate 10. The concrete gravity dam will be capable of storing water up to elevation 2,459 feet,

LIBBY DAM SITE – Looking upstream at preparatory work on the left and relocation of Montana State Highway 37 on the right. 30 August 1967

and the reservoir, which will have a total length of 90 miles, will extend some 42 miles into British Columbia. Procurement and preparation of the land required for the portion of the reservoir in Canada will, in accordance with the terms of the Treaty, be the obligation of the Canadian Government.

The dam will consist of non-overflow monoliths, powerhouse intake and spillway monoliths. The spillway monoliths will contain two radial-type crest gates, and the outlet works will be combined in the same section to utilize a common stilling basin. A roadway with sidewalks will be provided over the dam. The powerhouse will provide space for eight generating units for a total installed capacity of 840,000 kw, with an initial installation of 420,000 kw.

Relocation of the Great Northern Railroad, including excavation for a 7-mile railroad tunnel, and the construction of Forest Service Development Roads are on schedule. A contract for the construction of the dam in the approximate amount of $83 million was awarded on 10 March 1967 to Libby Dam Builders, a consortium of

Morrison-Knudsen Co.; Perini Corp.; McLaughlin, Inc.; Brown and Root Inc.; and F. and S. Contracting Co.; and initial operations are underway.

Hydrometeorological Network

One of the responsibilities assigned to the Entities by the Treaty is the establishment and operation, in consultation with the Permanent Engineering Board, of a hydrometeorological system to obtain data for detailed programming of flood control and power operation. This system will include snow courses, precipitation stations and streamflow gauges.

As described in the Board's previous Annual Reports, the Entities, with the concurrence of the Board, adopted requirements for the addition of a number of new snow courses and for additional reservoir and streamflow gauges to form part of the hydrometeorological network. The snow courses were established during the 1966 report year. Installation of the reservoir and streamflow gauges is proceeding satisfactorily.

SNOW AT MICA CREEK
Snow accumulated at the townsite during the first part of the winter.
22 December 1966

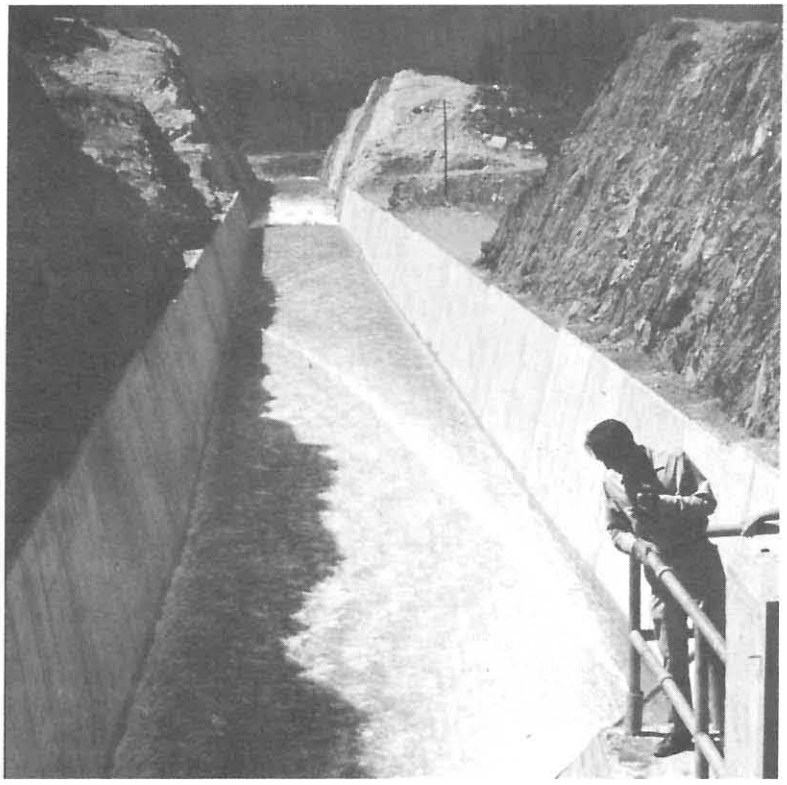
In this report year the Entities provided the Board with a document defining the Columbia River Treaty Hydrometeorological System Network and suggesting a method of dividing facilities into those required as part of the Treaty System and those of value as Supporting Facilities. The Board agreed with the Entities' proposal and subsequently received recommendations for dividing facilities into those two categories. The Entities also supplied the Board with recommendations regarding existing and new meteorological stations and additional snow courses which should be added to the general hydrometeorological network. The Board is considering these recommendations.

Reservoir Filling

The Entities continued studies of reservoir operation to develop an initial filling program for each of the Canadian storage reservoirs. These studies included an evaluation of the exchange of surplus electrical energy to assist in filling Mica reservoir.

During this report year the Entities adopted initial filling programs for the Arrow and Mica reservoirs and a filling program for the Duncan reservoir for the period 1 April 1968 to 30 June 1968. Initial filling of the Duncan reservoir occurred during the period of trial filling and test operation which was covered by the special operating program referred to in the following section. The Entities also completed a statistical analysis of the filling of the Mica reservoir.

CHUTE SPILLWAY
at the Duncan Project, looking down from the control structure.
2 August 1967



Power Operating Plans

The Treaty and related documents require that before the Duncan reservoir becomes fully operative the Entities must agree on operating plans and downstream power benefits for each year until 1 April 1973 when all three Canadian reservoirs are scheduled to be operative. In addition, commencing 1 April 1968, the Entities must determine annually both an assured plan of operation and the resulting downstream power benefits for the sixth succeeding year of operation.

In this report year the Entities agreed on procedures to be followed during a period of trial filling and test operation for the Duncan project and adopted a special operating program for the Duncan reservoir for the period 30 April 1967 through

31 March 1968. This program and the exchange of notes indicating approval by the two governments are attached as Appendix D. A supplemental operating program was provided for the final eight months of this period when the dam was declared operational on 31 July 1967.

The Entities completed studies to develop principles and procedures for the preparation and use of hydroelectric operating plans for the Canadian Treaty storages and provided the Board with a summary report.

The Entities continued to study procedures for determining downstream power benefits. They also carried out system regulation studies for the operating years 1968 through 1973 as a basis for the first assured operating plans which are scheduled for completion by January 1968.

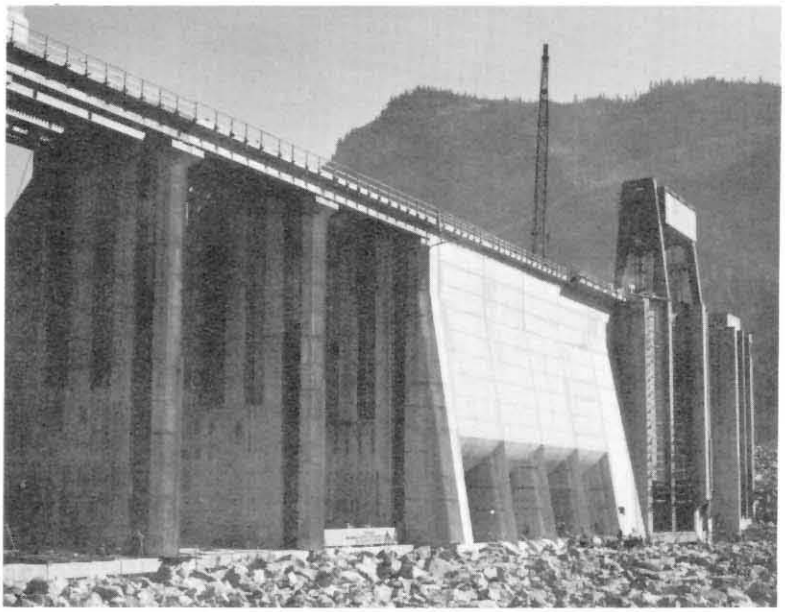
Flood Control Operating Plans

The Treaty provides that Canadian storage reservoirs will be operated by the Canadian Entity in accordance with operating plans designed to minimize flood damage in the United States and Canada.

During the report year the Entities continued studies to develop a flood control operating plan for the Canadian Treaty storage projects. Simulated forecasts of seasonal runoff volumes for the study period and flood-routing studies for the 1970 level of development were completed. Flood-routing studies for the 1975 level of development, which will include the Canadian projects and Libby, are continuing. A draft of the flood control operating plan has been prepared.

CONTROL STRUCTURES

at the Arrow Project. The upstream faces of the spillway openings, southern set of low-level ports, and navigation lock.
14 September 1967



Project Discharge Works

Paragraph 3 of Annex A of the Treaty specifies that sufficient discharge capacity will be provided at each of the Treaty dams to afford the desired regulation for power and flood control as mutually agreed on by the Entities.

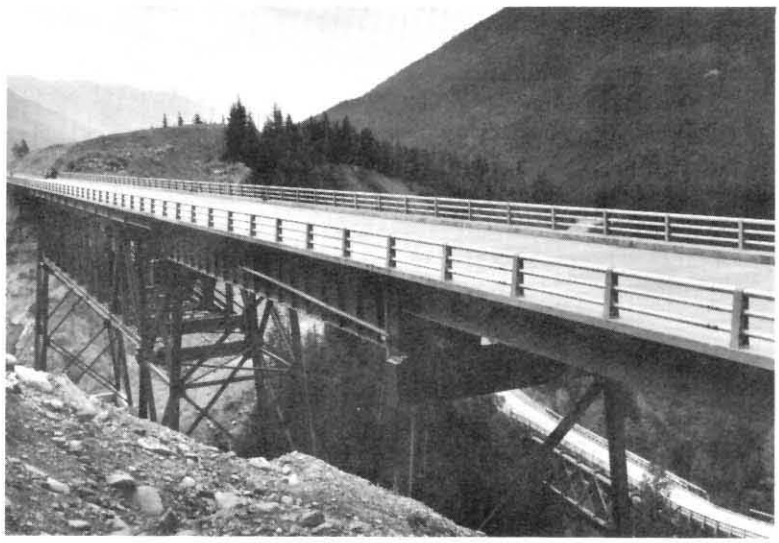
In the report year ending 30 September 1966 the Entities had agreed on discharge capacities for the Arrow and Duncan projects.

In this report year the Entities agreed that the minimum average weekly discharge from the Duncan project should be reduced from 1,000 to 100 cubic feet per second. The Entities continued their studies of discharge capacity for the Mica project.

Flow Records

Article XV(2)(a) of the Treaty specifies that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenay Rivers at the Canada–United States of America boundary.

In its previous annual report the Board noted that after the first Treaty project becomes operative actual flows at the International Boundary will be recorded and flows which would have occurred under pre-project conditions will be determined. In the section on benefits this report shows hydrographs of actual and pre-project flows for the Columbia River at Birchbank, British Columbia, near the International Boundary. In future reports the Board plans to record actual flows for the Kootenai River at Porthill, Idaho, and for the Columbia River at Birchbank, Plate 1, and also to show pre-project flows for Birchbank.



HOLDICH CREEK BRIDGE towering over the old bridge illustrates the standard of highway construction.
Mica Project,
12 July 1967

BENEFITS

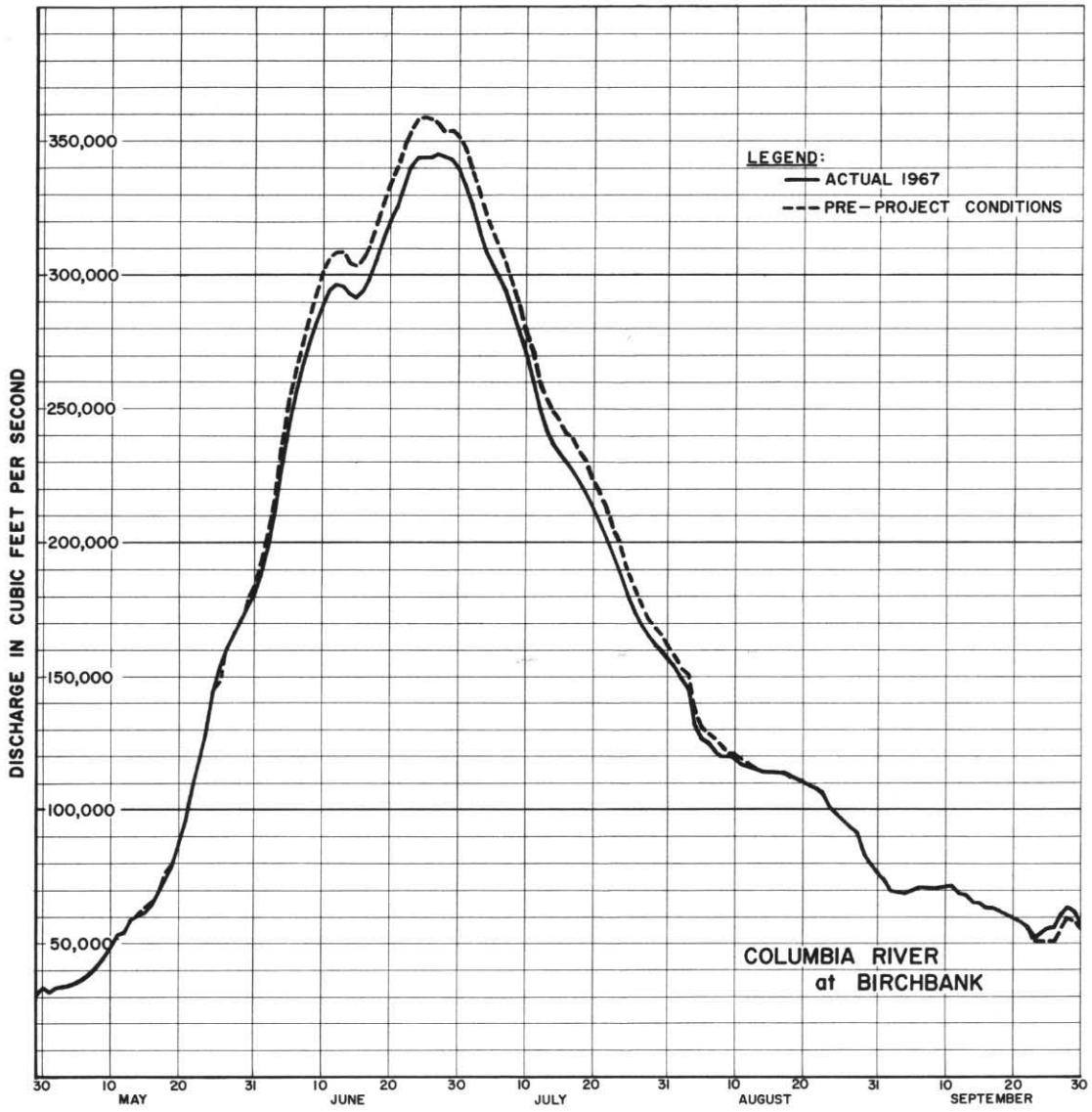
Flood Control Payment

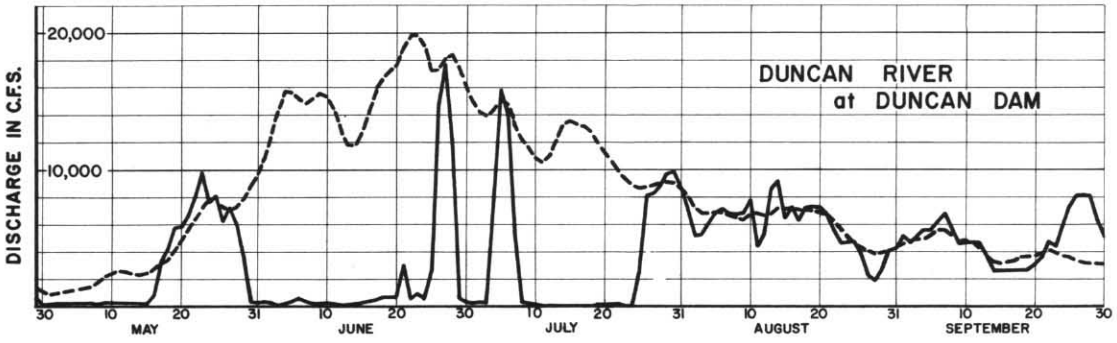
Article VI(1)(c) of the Treaty provides that the United States shall pay Canada $11,100,000 in United States funds upon commencement of operation of the storage at Duncan Dam. Funds for the flood control payment were included in the appropriations requests of the Corps of Engineers, United States Army, for the fiscal year 1968, but final action on these requests had not been taken by the United States Congress as of 30 September 1967.

Article IV(6) of the Treaty requires that the Duncan storage shall commence full operation by September 1969. As the project was placed in operation on 31 July 1967 the storage will be effective in providing flood control against the freshets in 1968 and 1969 in addition to the period provided for by the Treaty.

Flood Control Provided During the Test Filling Period

Although Duncan Dam was not declared operational until 31 July 1967 its operation during the test filling period was planned to provide maximum flood control downstream and at the same time to observe the filling restrictions necessary for the safety of the structure. The discharge tunnels were closed on 29 May 1967 and filling the reservoir was complete on 25 July 1967.





HYDROGRAPHS – The effect of the Duncan Project on 1967 flows.

The effect of storage in the Duncan reservoir on flows at the site and on the Columbia River at Birchbank is illustrated on page 31 by hydrographs which show actual discharges and "pre-project" flows that would have occurred if the dam had not been built. It is estimated that the Duncan project reduced the peak stage by about two feet on Kootenay Lake and by about 1.2 feet on the Columbia River at Trail, B.C. It also reduced the peak stage of the Kootenai River in the Bonners Ferry-Kootenai Flats area by about 0.6 feet.

Operation of the Columbia River basin reservoirs resulted in a nearly uniform flow of about 600,000 cfs in the lower Columbia River near The Dalles, Oregon, for a period of 19 days during the 1967 runoff period. Filling of the Duncan reservoir during that period effected an average reduction of about 13,000 cfs. The observed peak stage on the Columbia River at Vancouver, Washington, was 21.48 feet; without storage in the Duncan reservoir it would have been about 0.4 feet higher.

Power Benefits

The special operating program for Duncan reservoir made provision for delivery of additional downstream power benefits during the period 1 April 1967 to 31 March 1968. To the end of this report year a total of 412,926,000 kilowatt hours of electrical energy had been received by the Canadian Entity under this program.

CONCLUSIONS

1. Duncan Dam is complete. The Arrow dam is ahead of schedule and the Mica and Libby projects are proceeding on schedule.

2. Entity studies on project discharge capacities, the hydrometeorological network, reservoir filling and power and flood control operation are proceeding satisfactorily.

3. Finally, the Board concludes that the objectives of the Treaty are being met.

APPENDIX A

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

United States	Canada
Members	
Mr. Wendell E. Johnson, Chairman Chief, Engineering Division, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.	Mr. G.M. MacNabb, Chairman Assistant Deputy Minister, Energy Development, Department of Energy, Mines and Resources, Ottawa, Ontario
Mr. Morgan D. Dubrow Assistant and Chief Engineering Research Advisor, Office of the Assistant Secretary for Water and Power Development, Department of the Interior, Washington, D.C.	Mr. A.F. Paget Deputy Minister of Water Resources, Department of Lands, Forests, and Water Resources, Victoria, B.C.
Alternates	
Mr. Fred L. Thrall Chief, Water Conservation Branch, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.	Mr. E.M. Clark Engineer, Inland Waters Branch, Department of Energy, Mines and Resources, Vancouver, B.C.
Mr. J. Emerson Harper Engineering Assistant, Office of the Assistant Secretary for Water and Power Development, Department of the Interior, Washington, D.C.	Mr. H.M. Hunt Chief, Power and Major Licences Division, Water Resources Service, Department of Lands, Forests, and Water Resources, Victoria, B.C.
Secretaries	
Mr. John W. Roche Engineer, Planning Division, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.	Mr. E.M. Clark Engineer, Inland Waters Branch, Department of Energy, Mines and Resources, Vancouver, B.C.

APPENDIX B

COLUMBIA RIVER TREATY ENTITIES

United States

Mr. H.R. Richmond, Acting Chairman (1)

Deputy Administrator, Bonneville Power Administration,
Department of the Interior,
Portland, Oregon

Brigadier General Elmer P. Yates (2)

Division Engineer, North Pacific Division,
Corps of Engineers, U.S. Army,
Portland, Oregon

Canada

Dr. H.L. Keenleyside, Chairman

Co-chairman, British Columbia Hydro and Power Authority,
Vancouver, B.C.

(1) Vice the Honorable David S. Black, Undersecretary of the Department of the Interior, Washington, D.C. as of 14 August 1967.

(2) Vice Brigadier General Peter C. Hyzer as of 1 February 1967.

APPENDIX C

ADMINISTRATION AND PROCEDURES

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

Administration and Procedures

1. Authority. The four-man Permanent Engineering Board was created, and its general duties outlined, by the "Treaty Between Canada and the United States of America Relating to Co-operative Development of the Water Resources of the Columbia River Basin" signed at Washington, D.C. on January 17, 1961, and the Annex to an Exchange of Notes dated January 22, 1964. The United States Section of the Board was provided for by Presidential Executive Order No. 11177 dated September 16, 1964. The Canadian Section of the Board was established by Order-in-Council P.C. 1964–1671 dated October 29, 1964 as amended by P.C. 1964–1976 dated December 17, 1964.

2. Composition of the Board. In conformance with Article 6(2) of the Canada-British Columbia Agreement of July 8, 1963 relating to the Treaty, and Order-in-Council 1964–1671, the Canadian Section of the Permanent Engineering Board shall consist of one member to be nominated and appointed by the Government of Canada who shall be Chairman of the Canadian Section, and one member to be nominated by the Province of British Columbia and appointed by the Government of Canada. In accordance with Order-in-Council P.C. 1964–1976 each member shall designate an alternate to serve for and in the member's absence.

In accordance with Presidential Executive Order No. 11177 the United States Section of the Permanent Engineering Board shall consist of one member designated by the Secretary of the Army who shall be Chairman of the United States Section, and one member designated by the Secretary of the Interior. In accordance with that same Order each member shall have a designated alternate to serve for and in the member's absence.

3. Chairman. The Chairman of each Section of the Board shall preside as Chairman of the Board as a whole at all meetings of the Board held in his country. In the event the Chairman of either Section of the Board is absent the chairmanship of that Section and, if appropriate, of the Board itself shall be assumed by the other member of that Section, or if that member is also absent, by the alternate to the Chairman of that Section.

4. General Duties of the Board. As set forth in the Columbia River Treaty and related documents the general duties of the Board include:

(a) assembling records of the flows of the Columbia River and the Kootenay River at the Canada-United States of America boundary;

(b) reporting to Canada and the United States of America whenever there is substantial deviation from the hydro-electric and flood control operating plans and if appropriate including in the report recommendations for remedial action and compensatory adjustments;

(c) assisting in reconciling differences concerning technical or operational matters that may arise between the entities;

(d) making periodic inspections and requiring reports as necessary from the entities with a view to ensuring that the objectives of the Treaty are being met;

(e) making reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and making special reports concerning any matter which it considers should be brought to their attention;

(f) investigating and reporting with respect to any other matter coming within the scope of the Treaty at the request of either Canada or the United States of America;

(g) consulting with the entities in the establishment and operation of a hydro-meteorological system as required by Annex A of the Treaty.

5. Meetings. The Board shall meet at such times and places as the Chairmen of the two Sections consider necessary or desirable to properly discharge the responsibilities of the Board. A quorum shall require each member of the Board to be present or represented by an alternate acting on his behalf.

6. Minutes of Board Meetings. The Chairman of each Section shall appoint a Secretary. The Secretary shall be the official recorder of the Board minutes when the Chairman of his Section is presiding. Each Secretary shall exchange and preserve an authentic copy of the minutes approved by the Board. A draft copy of the minutes will, within fifteen days after the meeting, be sent by the recording Secretary to each member of the Board for review and comments, and the comments shall be received by the Secretary within the next thirty days unless otherwise specified and agreed to by the Board. The minutes will be considered for adoption at the next Board meeting. Copies of approved minutes will be supplied to all Board members by the recording Secretary.

7. Engineering Committees. The Board may designate special Engineering Committees to assist in the performance of the Board's functions. Except as otherwise agreed by the Board, these committees will have an equal number of members from each country. The members will be qualified individuals in their respective fields and they need not necessarily be officers or employees of the Governments of the two countries. Members of the committees will be designated by the Chairman of each Section and will serve for such periods as he may determine.

8. Technical and Administrative Assistance. The respective Sections of the Board shall be provided with the technical and administrative assistance they require through:

(a) the provision of Board staff,

(b) the utilization of services available from departments or agencies of their respective Governments, and

(c) the retention of consulting engineering services.

9. Reports. As required by Article XV of the Treaty the Board will make reports to the Governments of Canada and the United States at least once a year. Reports to the Governments shall be made through the Minister of Northern Affairs and National Resources for Canada and the Secretary of State for the United States. The initial report by the Board will be submitted by December 31, 1965.

10. Expenses. Except as otherwise agreed by the Board each Government shall, in accordance with the usual budgetary practices, bear the expenses authorized by its own Section of the Board and incurred by or on behalf of that Section in carrying out its duties.

11. Communication with the Entities. Communication between the Board and the entities of the two countries will be through the offices of the respective Chairmen.

12. Rules and Regulations. The Board is empowered to make only such supplementary rules and regulations as are consistent with the procedures defined herein in order to carry out its duties and responsibilities as set forth in the Treaty.

APPENDIX D

EXCHANGE OF NOTES

RELATING TO

THE SPECIAL OPERATING PROGRAM FOR THE DUNCAN RESERVOIR

Ottawa, May 8, 1967

No. X-198

Excellency,

I have the honour to refer to the Treaty between Canada and the United States of America relating to the co-operative development of water resources of the Columbia River Basin signed at Washington, D.C. on January 17, 1961, and in particular to Article XIV(4).

It now appears likely that the discharge works of the project specified in Article II(2)(c) of the Treaty will be closed on or about April 30, 1967 and that a trial filling and test operation period will be necessary before commencement of full operation of the project.

This possibility has been recognized by the United States and Canadian entities, and they have agreed upon special arrangements for a trial operation should circumstances described in the immediately preceding paragraph occur. These arrangements are described in the attached document entitled, "Columbia River Treaty: Special Operating Program for the Duncan Reservoir for the Period April 30, 1967 through March 31, 1968".

I have the honour to propose that this special operating program be made effective and confirmed by our two Governments and that the two Governments empower and charge the entities, pursuant to Article XIV(4) of the Treaty to carry out its provisions.

I have the honour further to propose that, if this proposal meets with the approval of the Government of the United States of America, this note and attachment thereto, together with your reply, shall constitute an agreement between our two Governments relating to the Treaty with effect from April 1, 1967.

Accept, Excellency, the renewed assurances of my highest consideration.

"Paul Martin"

Secretary of State for
External Affairs

His Excellency

W. Walton Butterworth

Ambassador of the United States of America

Ottawa

COLUMBIA RIVER TREATY

SPECIAL OPERATING PROGRAM FOR THE DUNCAN RESERVOIR FOR THE PERIOD APRIL 30, 1967 THROUGH MARCH 31, 1968

1. INTRODUCTION

It is anticipated the discharge works of the Duncan Project will be closed on or about April 30, 1967; however, before the reservoir becomes fully operative for power purposes on April 1, 1968, in accordance with Section A(1)(a) of the Attachment Relating to Terms of Sale, a trial filling and test operation period is necessary to ensure that the dam adjusts satisfactorily to the increasing water pressure and that control gates and other hydraulic structures and facilities perform correctly. Implementation of this Special Operating Program is subject to closure of the discharge works of the Duncan Project with commencement of the trial filling of the reservoir.

2. CANADIAN SHARE

It is the intent of this Special Operating Program to recognize the energy benefit that might result at downstream United States hydro plants from the operation of the Duncan reservoir during the period April 30, 1967 – March 31, 1968. It also sets out the criteria which will govern the operation of the project and the delivery to the Canadian Entity of the Canadian share of the potential downstream United States energy benefit from Duncan storage, which share is agreed to be 34,770 megawatt-days of energy delivered at Blaine, Washington (100 average megawatts less 5% transmission

losses, based on the availability of 1.4 million acre-feet usable storage content in Duncan reservoir on July 31, 1967). The Power benefits considered herein are limited to energy benefits since dependable capacity is not assured.

3. TRIAL FILLING OF DUNCAN RESERVOIR

The trial filling of Duncan reservoir shall be as directed by the Canadian Entity. However, if releases greater than minimum are required to meet co-ordinated system load requirements in the United States after making full use of its hydroelectric resources consistent with Energy Content Curves, the Canadian Entity shall fulfill requests of the United States Entity to pass a flow not greater than the inflow to Duncan reservoir.

4. ADVANCE DELIVERY OF CANADIAN SHARE

Beginning on April 1, 1967, and continuing until July 31, 1967, the United States Entity will advance to the Canadian Entity 11,590 megawatt-days of energy, to be delivered in uniform weekly amounts. This advanced delivery of energy may be curtailed should the Canadian Entity request, but in this case the energy which is foregone shall not be delivered later. Details of delivery are further discussed in paragraph 10 below.

5. ADJUSTMENT OF CANADIAN SHARE

On August 1, 1967, the Canadian Share will be adjusted by multiplying the precomputed 34,770 megawatt-days by the ratio that the usable storage in acre-feet

actually filled in Duncan reservoir by July 31, 1967, bears to 1.4 million acre-feet.

$$\text{Canadian Share} = 34{,}770 \ \frac{(A)}{(1.4)} \quad \text{megawatt-days}$$

Where A = usable storage content in million acre-feet in Duncan on July 31, 1967.

6. RATE OF DELIVERY OF CANADIAN SHARE

If, by July 31, 1967, the Canadian Entity informs the United States Entity the Duncan reservoir is available for storage regulation as described in paragraph 11, and:

(a) if Duncan reservoir fills to its full storage content of 1.4 million acre-feet by July 31, 1967, the United States will continue the delivery of the remainder of the Canadian Share, in uniform weekly amounts until March 31, 1968.

(b) if the storage content of the Duncan reservoir is less than 1.4 million acre-feet on July 31, 1967, the Canadian Share shall be computed as described in paragraph 5 less 11,590 megawatt-days. The remaining megawatt-days so determined shall be divided by 244 days to determine the rate of delivery of the Canadian Share in uniform weekly amounts for the period August 1, 1967, to March 31, 1968.

$$\text{Canadian Share} = \frac{34{,}770 \ \frac{(A)}{(1.4)} - 11{,}590}{244} \quad \text{average megawatts}$$

7. CURTAILMENT OF DELIVERY OF CANADIAN SHARE AND DISPOSITION OF ENERGY PREVIOUSLY DELIVERED

If the Canadian Entity has not informed the United States Entity by July 31, 1967, that the Duncan reservoir is available for storage regulation, delivery of the Canadian Share shall be discontinued on July 31, 1967. Moreover, if Duncan reservoir is not available for regulation by December 31, 1967, any portion of the advanced delivery of the Canadian Share during the period April 1, 1967, through July 31, 1967, which was not delivered from surplus United States energy will be returned as requested by the United States Entity if needed to meet loads in the United States prior to March 31, 1968, on schedules as agreed by the Entities. Advance delivery that was made from surplus United States energy plus any returnable energy for which return is not requested, will be transferred to the credit of Bonneville Power Administration in an exchange energy account between British Columbia Hydro and Power Authority and Bonneville Power Administration at the Bonneville Power Administration Schedule S-1 wholesale excess energy rate currently in effect.

8. NOTIFICATION OF AVAILABILITY OF DUNCAN RESERVOIR AFTER JULY 31, 1967.

If the Canadian Entity notifies the United States Entity that the Duncan reservoir is available for storage regulation after July 31, 1967, the United States Entity shall immediately resume delivery of the Canadian Share to the Canadian Entity and continue to deliver such energy for the remainder of the period ending March 31, 1968, at a rate computed as described below.

(a) If notification of availability is given prior to December 31, 1967, the Canadian Share will be computed according to the formula in paragraph 6(b).

(b) If notification of availability is given after December 31, 1967, the Canadian Share will be computed as follows:

$$\text{Canadian Share} = 95 \frac{(A^1)}{(1.4)} D \quad \text{megawatt-days}$$

Where D = the number of days from the date of notification through March 31, 1968.

A^1 = usable storage content in million acre-feet in Duncan on date of notification.

In no case will the weekly delivery exceed the average rate of 95 megawatts unless otherwise agreed.

During the period following July 31, 1967, and prior to the date on which notification is given, no deliveries of the Canadian Share shall be made to the Canadian Entity unless otherwise agreed.

9. ADJUSTMENT FOR ADDITIONAL STORAGE IN DUNCAN RESERVOIR DURING AUGUST 1967

If the Duncan reservoir has been declared available for regulation by July 31, 1967, and the reservoir is not full to 1.4 million acre-feet on this date, any further filling of the reservoir during August 1967 will be as requested by the United States Entity in consultation with the Canadian Entity. Any additional storage thus filled in Duncan reservoir during August 1967 will be included in computations of the Canadian Share and rates of delivery will be increased accordingly following August 31, 1967,

as described in paragraphs 5 and 6 except that "A" will be the actual usable storage content in millions of acre-feet in Duncan on August 31, 1967.

10. DELIVERY OF CANADIAN SHARE

In any day the Canadian Share shall be delivered by Bonneville Power Administration at Blaine as scheduled by British Columbia Hydro and Power Authority to the extent that facilities and operating limitations permit but in no case will exceed a rate of 180 megawatts. Wheeling charge will be $.0005 per kilowatt hour unless otherwise agreed by the Entities.

11. OPERATION DURING TEST OPERATION PERIOD

During the period July 31, 1967, through March 31, 1968, beginning when Duncan becomes available for storage regulation, the Duncan reservoir will be operated by the Canadian Entity as requested by the United States Entity guided by an Operating Rule Curve mutually agreed in advance. Such Operating Rule Curve will be based on a Critical Rule Curve and on Reservoir Refill Curves which include a volume-of-runoff forecast parameter. Construction of these curves and their use in actual operation of Duncan reservoir will be in general agreement with the procedures of the Pacific Northwest Co-ordinated Systems.

12. FLOOD CONTROL CONSIDERATIONS

During the Special Operating Program the Entities agree that every effort will be made to preclude adding to the flood hazard downstream from Duncan reservoir. Should it become necessary to evacuate Duncan storage content during the high-water

period, the Canadian Entity in consultation with the United States Entity, will attempt to accomplish this evacuation in a manner least detrimental to flood-control operation.

13. DELAYED DELIVERIES

If deliveries of energy by either party to the other are delayed due to uncontrollable forces, such deliveries shall be made at a time and at a rate agreed by the Entities.

14. APPLICABILITY OF TREATY

This document is subject to the provisions of the Treaty.

Ottawa, May 18, 1967

No. 292

Sir:

I have the honor to refer to your Note of May 8, 1967 and the document attached thereto, concerning the Special Operating Program for the project specified in Article II(2)(c) of the 1961 Columbia River Treaty.

I wish to advise that the Government of the United States of America accepts the proposals set forth in your Note and agrees that your Note and attachment together with this reply shall constitute an agreement between our two Governments relating to the Treaty with effect from April 1, 1967.

Accept, Sir, the renewed assurances of my highest consideration.

"W.W. Butterworth"

Ambassador

The Honorable

Paul Martin,

Secretary of State

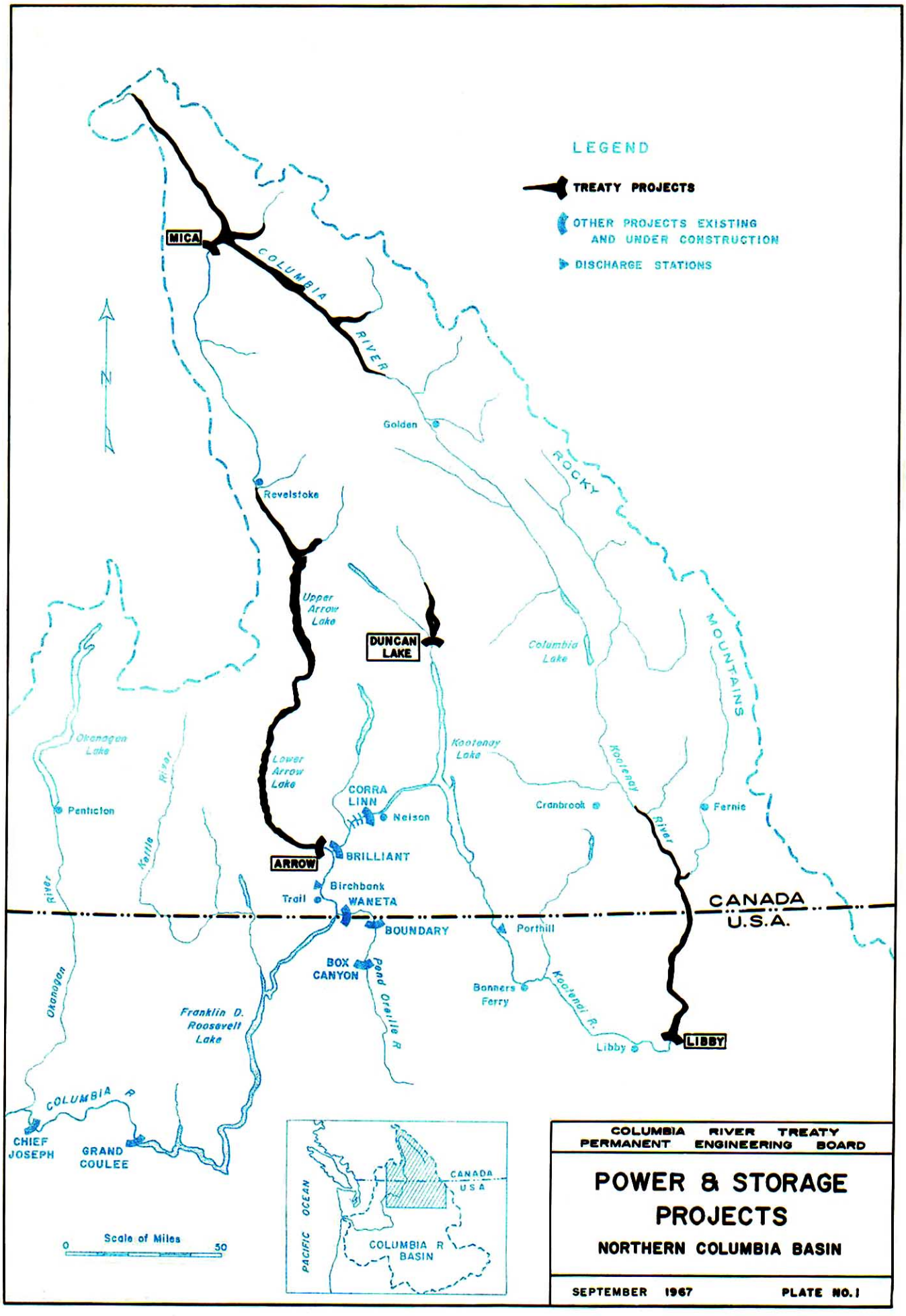
for External Affairs,

Ottawa

APPENDIX E

LIST OF PLATES

	Plate No.
Power and Storage Projects, Northern Columbia Basin	1
Duncan Project, General Arrangement	2
Duncan Project, Chute Spillway, Discharge Works and Earth Dam	3
Arrow Project, General Arrangement	4
Arrow Project, Progress Chart of Earth Dam	5
Mica Project, General Arrangement	6
Mica Project, Diversion Tunnels	7
Mica Project, Highway Relocation	8
Libby Project, General Arrangement	9
Libby Project, Reservoir Area	10


LEGEND
TREATY PROJECTS
OTHER PROJECTS EXISTING AND UNDER CONSTRUCTION
DISCHARGE STATIONS
MICA
COLUMBIA RIVER
N
Golden
ROCKY MOUNTAINS
Revelstoke
Upper Arrow Lake
DUNCAN LAKE
Columbia Lake
Okanagan Lake
Lower Arrow Lake
Kootenay Lake
Kootenay River
CORRA LINN
Nelson
Cranbrook
Fernie
Penticton
Kettle River
ARROW
BRILLIANT
Birchbank
Trail
WANETA
CANADA
U.S.A.
BOUNDARY
Porthill
BOX CANYON
Pend Oreille R
Okanogan River
Franklin D. Roosevelt Lake
Bonners Ferry
Kootenai R.
Libby
LIBBY
COLUMBIA R
CHIEF JOSEPH
GRAND COULEE
Scale of Miles
0
50
PACIFIC OCEAN
CANADA
USA
COLUMBIA R BASIN
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
POWER & STORAGE PROJECTS
NORTHERN COLUMBIA BASIN
SEPTEMBER 1967
PLATE NO. 1

DUNCAN RIVER

IMPERVIOUS BLANKET

N

1800
1850
1900
1950
2000
2050

EL. 1779

WEST OR RIGHT ABUTMENT

TUNNEL NO. 2

TUNNEL NO. 1

RESERVOIR FULL SUPPLY LEVEL EL. 1892

CREST OF DAM EL. 1907

1850
1900
1950
2000
2025
2050
2075

EL. 1848

EAST OR LEFT ABUTMENT

OUTLET STRUCTURE

DRAINAGE DITCH

MAX. EL. 1805

EL. 1780

DOWNSTREAM DYKE

EL. 1805

OUTLET CHANNEL

DISCHARGE MEASURING STATION

WEST ABUTMENT ROAD

1925
1900
1875

0 100 300 500
SCALE IN FEET

2000
1950

SPILLWAY CHUTE

OUTLET CHANNEL

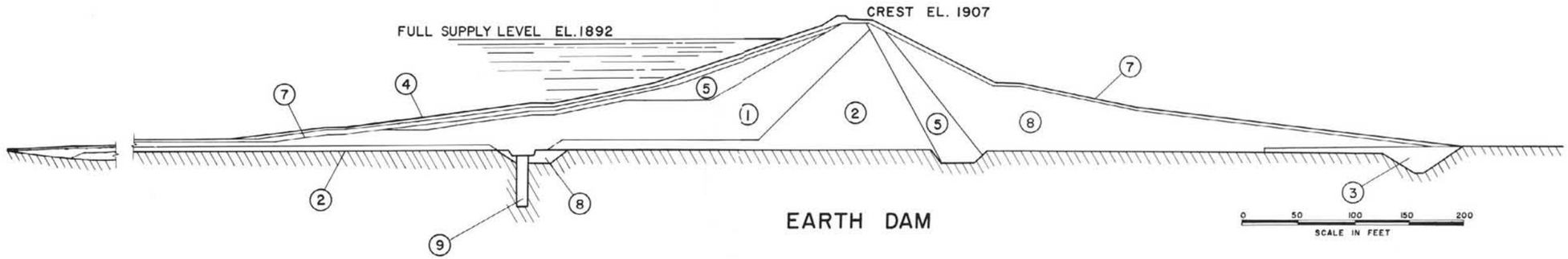
PLAN PREPARED FROM DETAILED DRAWINGS SUPPLIED BY B.C. HYDRO & POWER AUTHORITY

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

DUNCAN PROJECT

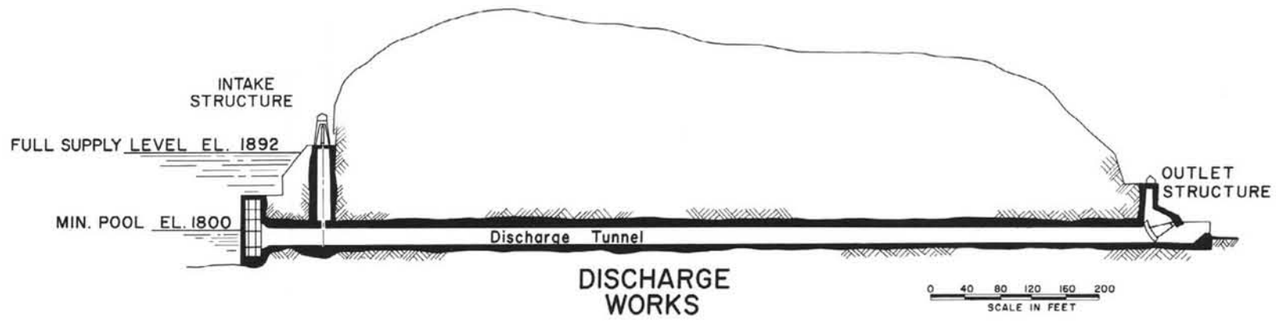
GENERAL ARRANGEMENT

SEPTEMBER 1967 PLATE NO. 2

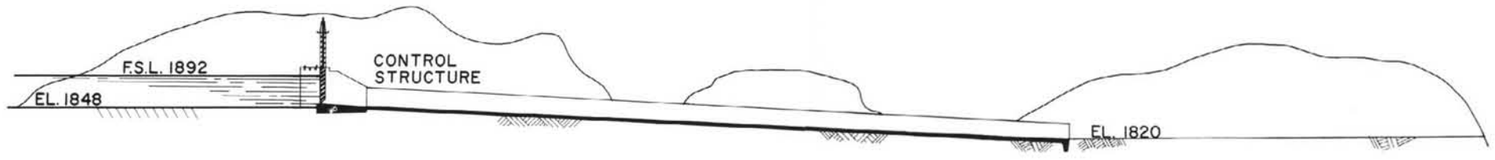


EARTH DAM

ZONE	MATERIAL
1	IMPERVIOUS FILL
2	SEMI PERVIOUS FILL
3	PROCESSED FILTER
4	RIP RAP
5–8	PERVIOUS FILL VARIOUS GRADINGS
9	IMPERVIOUS CUT–OFF WALL



DISCHARGE WORKS



CHUTE SPILLWAY

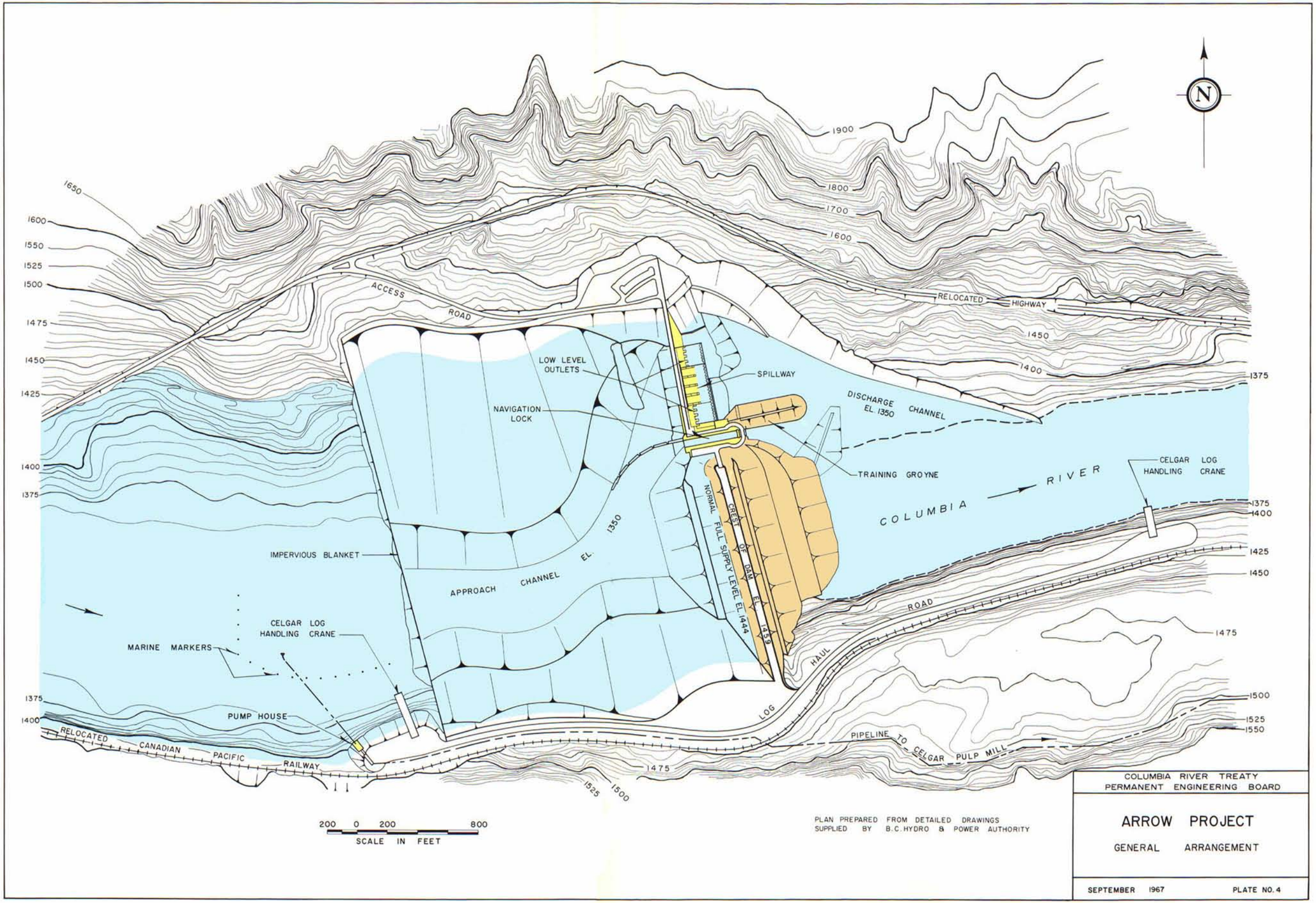
PLAN PREPARED FROM DETAILED DRAWINGS SUPPLIED BY B.C. HYDRO & POWER AUTHORITY

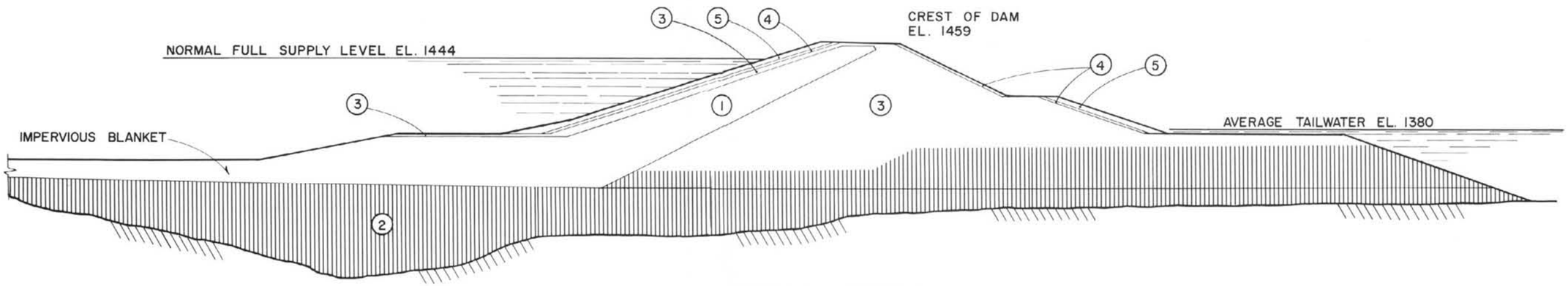
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

DUNCAN PROJECT

CHUTE SPILLWAY,
DISCHARGE WORKS & EARTH DAM

SEPTEMBER 1967 PLATE NO. 3


N
1900
1800
1700
1600
1650
1600
1550
1525
1500
1475
1450
1425
1400
1375
ACCESS ROAD
RELOCATED HIGHWAY
1450
1400
1375
LOW LEVEL OUTLETS
SPILLWAY
NAVIGATION LOCK
DISCHARGE CHANNEL
EL 1350
TRAINING GROYNE
CELGAR LOG HANDLING CRANE
RIVER
COLUMBIA
NORMAL FULL SUPPLY LEVEL EL. 1444
CREST OF DAM EL. 1459
IMPERVIOUS BLANKET
APPROACH CHANNEL EL. 1350
CELGAR LOG HANDLING CRANE
MARINE MARKERS
PUMP HOUSE
RELOCATED CANADIAN PACIFIC RAILWAY
HAUL ROAD
LOG
PIPELINE TO CELGAR PULP MILL
1375
1400
1425
1450
1475
1500
1525
1550
200 0 200 800
SCALE IN FEET
PLAN PREPARED FROM DETAILED DRAWINGS SUPPLIED BY B.C. HYDRO & POWER AUTHORITY
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
ARROW PROJECT
GENERAL ARRANGEMENT
SEPTEMBER 1967
PLATE NO. 4



TYPICAL SECTION OF EARTH DAM

AVERAGE SHAPE OF COMPLETED FILL

ZONE	MATERIAL
1	IMPERVIOUS FILL
2	SAND & GRAVEL FILL
3	PERVIOUS FILL
4	RIP RAP BEDDING
5	RIP RAP

0 50 100 150 200
SCALE IN FEET

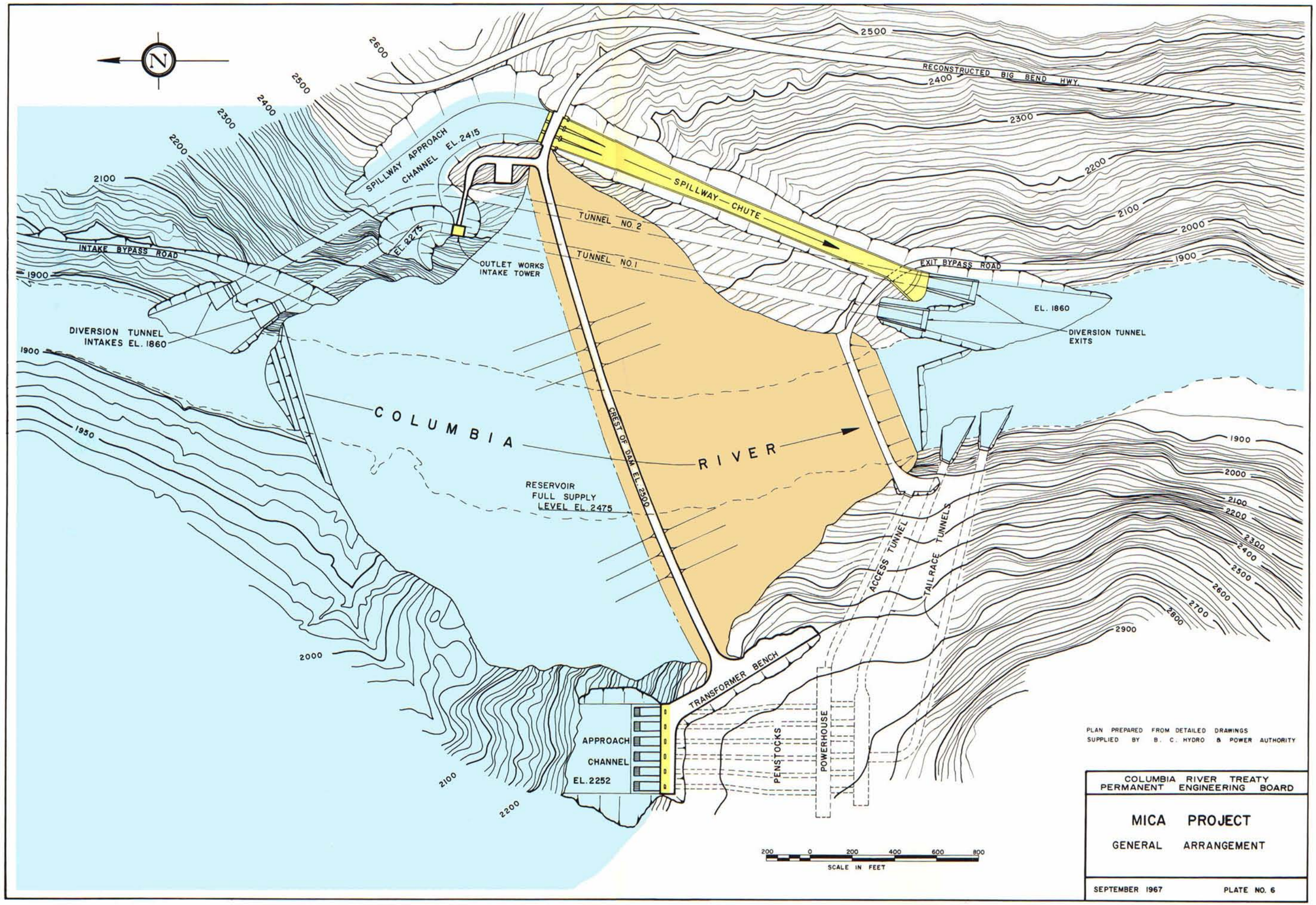
PLAN PREPARED FROM DETAILED DRAWINGS SUPPLIED BY B.C. HYDRO & POWER AUTHORITY

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

ARROW PROJECT

PROGRESS CHART
OF
EARTH DAM

SEPTEMBER 1967 PLATE NO. 5



PLAN PREPARED FROM DETAILED DRAWINGS SUPPLIED BY B. C. HYDRO & POWER AUTHORITY

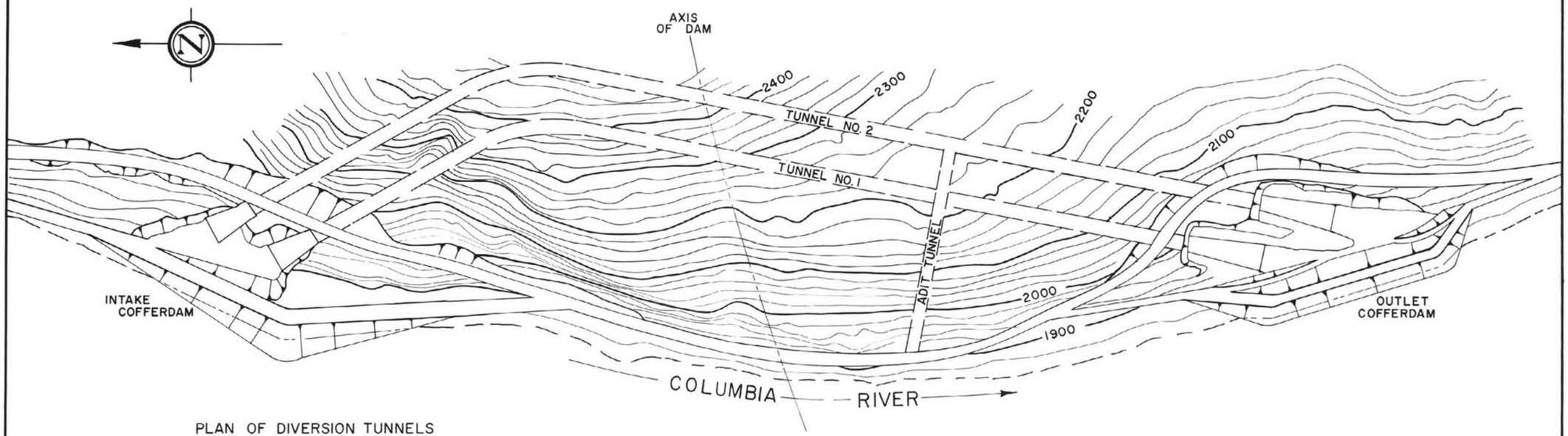
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

MICA PROJECT

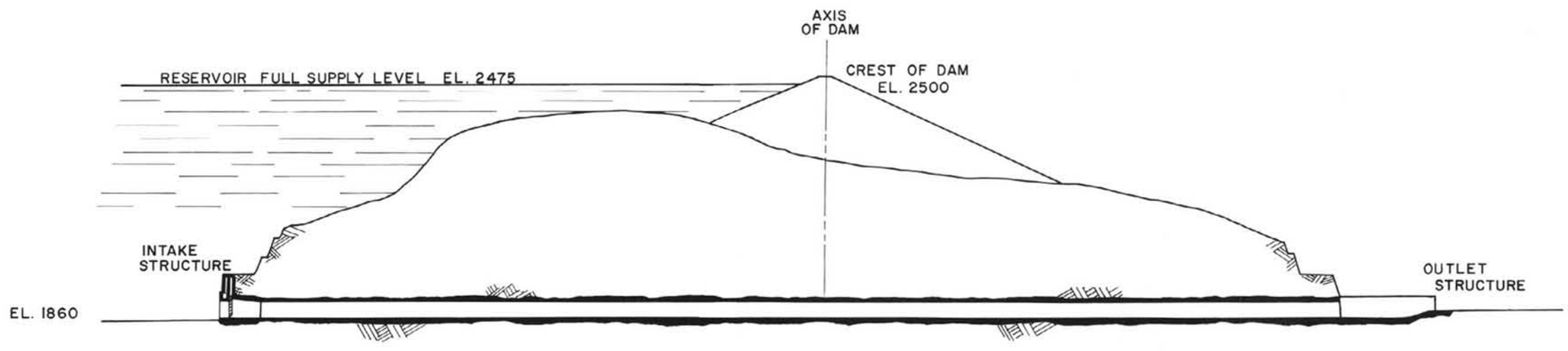
GENERAL ARRANGEMENT

SEPTEMBER 1967

PLATE NO. 6



PLAN OF DIVERSION TUNNELS
EXCAVATION AND COFFERDAMS



TYPICAL TUNNEL SECTION
— COMPLETED CONCRETE

200 0 200 400 600
SCALE IN FEET

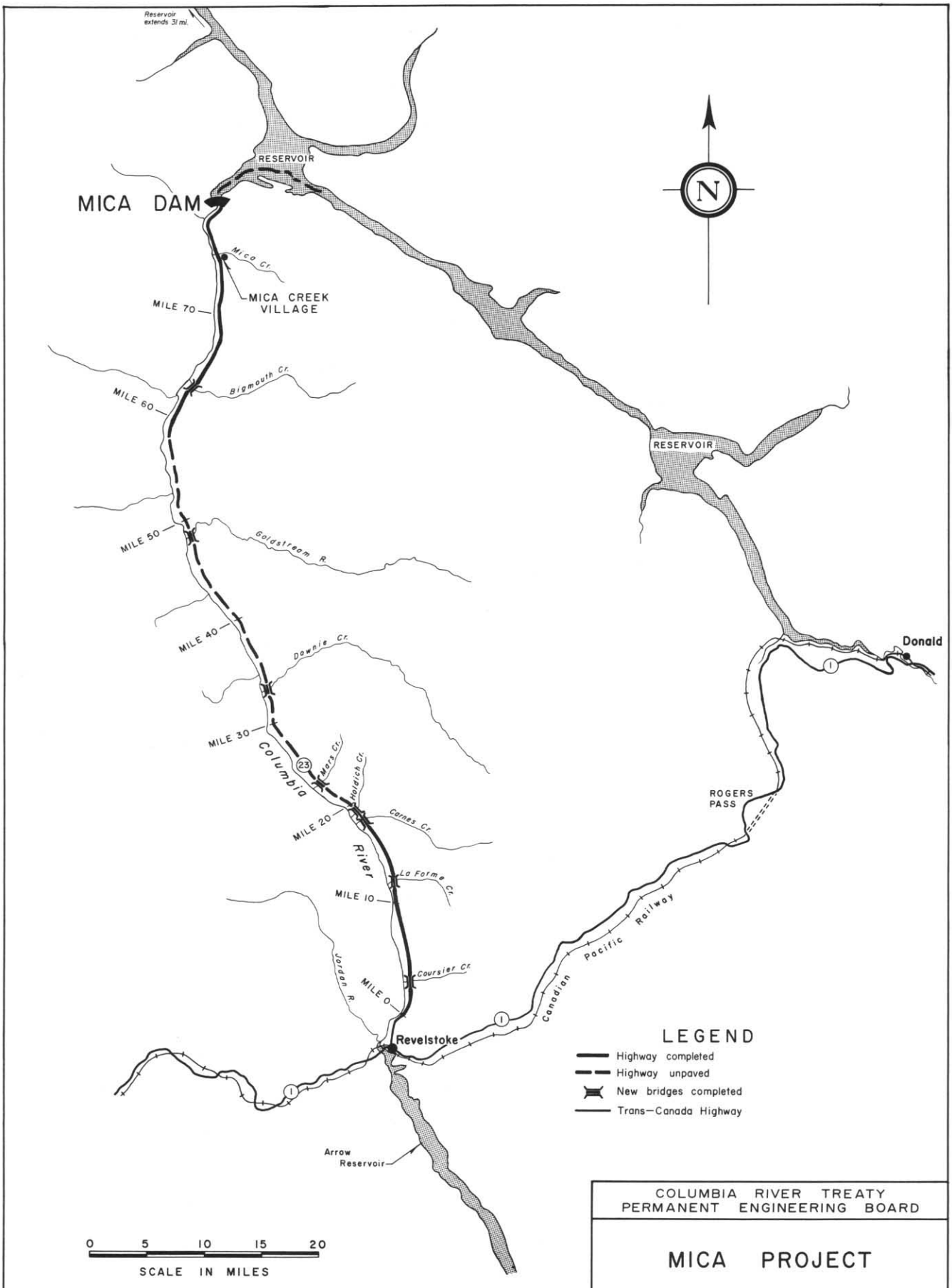
PLAN PREPARED FROM DETAILED DRAWINGS SUPPLIED BY B. C. HYDRO & POWER AUTHORITY

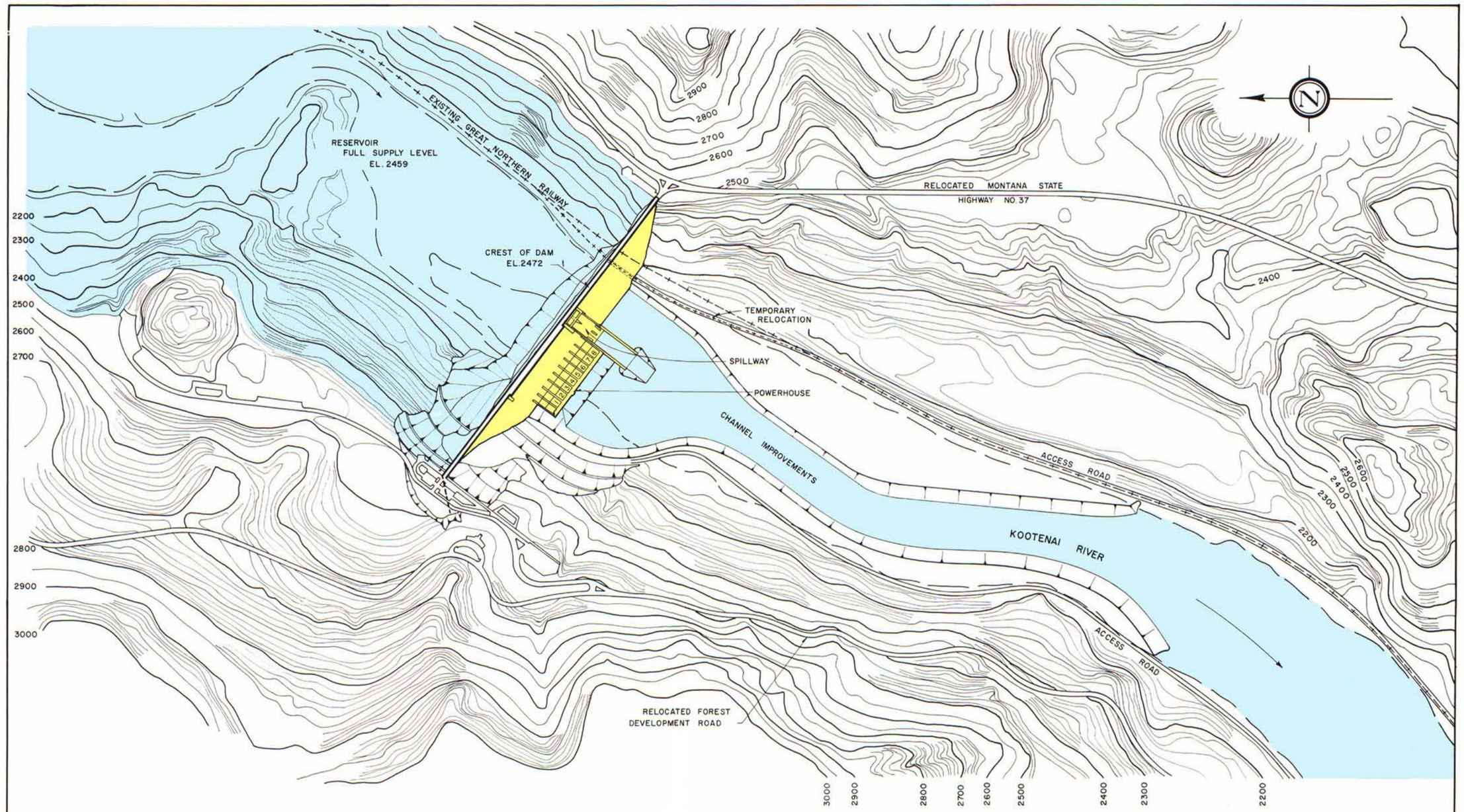
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

MICA PROJECT

DIVERSION TUNNELS

SEPTEMBER 1967 PLATE NO. 7


Reservoir extends 31 mi.
RESERVOIR
MICA DAM
Mica Cr.
MICA CREEK VILLAGE
MILE 70
Bigmouth Cr.
MILE 60
RESERVOIR
MILE 50
Goldstream R.
MILE 40
Downie Cr.
Donald
MILE 30
Columbia
Mars Cr.
Holdich Cr.
ROGERS PASS
MILE 20
Carnes Cr.
River
La Forme Cr.
MILE 10
Canadian Pacific Railway
Jordan R.
Coursier Cr.
MILE 0
Revelstoke
Arrow Reservoir
N
LEGEND
Highway completed
Highway unpaved
New bridges completed
Trans—Canada Highway
0 5 10 15 20
SCALE IN MILES
PLAN PREPARED FROM DETAILED DRAWINGS SUPPLIED BY B.C. HYDRO & POWER AUTHORITY
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
MICA PROJECT
HIGHWAY RELOCATION
SEPTEMBER 1967
PLATE NO. 8



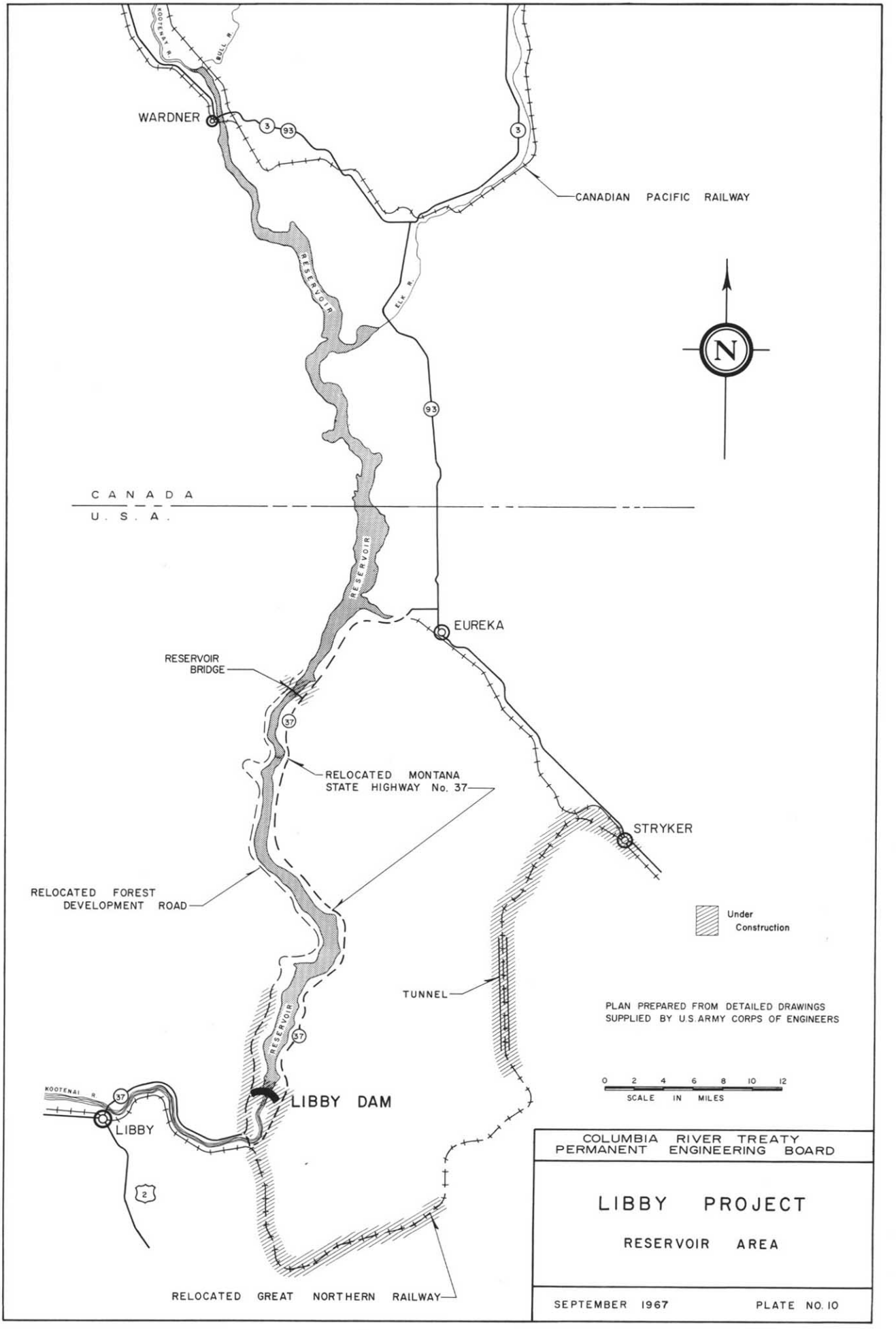
PLAN PREPARED FROM DETAILED DRAWINGS SUPPLIED BY U.S. ARMY CORPS OF ENGINEERS

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

LIBBY PROJECT

GENERAL ARRANGEMENT

SEPTEMBER 1967 PLATE NO. 9


KOOTENAI R.
BULL R.
WARDNER
3
93
3
CANADIAN PACIFIC RAILWAY
RESERVOIR
ELK R.
N
93
CANADA
U. S. A.
RESERVOIR
EUREKA
RESERVOIR BRIDGE
37
RELOCATED MONTANA STATE HIGHWAY No. 37
STRYKER
RELOCATED FOREST DEVELOPMENT ROAD
Under Construction
TUNNEL
PLAN PREPARED FROM DETAILED DRAWINGS SUPPLIED BY U.S. ARMY CORPS OF ENGINEERS
RESERVOIR
37
0 2 4 6 8 10 12
SCALE IN MILES
KOOTENAI R.
37
LIBBY DAM
LIBBY
2
RELOCATED GREAT NORTHERN RAILWAY
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
LIBBY PROJECT
RESERVOIR AREA
SEPTEMBER 1967
PLATE NO. 10